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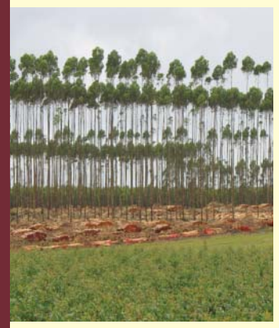
Special Issue: The Forestry Sector and other Land Uses in relation to Climate Change in Africa



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Mutually beneficial company-community partnership in ensuring its long-term viability: emerging lessons from Indonesia

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  Paper or chapter in proceedings
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Contents

PAPERS

Agriculture, forestry and other land uses in Nationally Determined Contributions: the outlook for Africa

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SUMMARY

This paper sought to examine how Agriculture, Forestry and Other Land Use (AFOLU) activities and their contributions are represented in the post 2020 climate change commitments of African countries and assess the necessary conditions for their successful implementation. Secondary data on Nationally Determined Contributions (NDCs) was collected from 52 African countries whereas primary data was obtained from Madagascar, Democratic Republic of Congo, Cameroon, Côte d'Ivoire and Burkina Faso. Qualitative and quantitative data analysis approaches were used. The study revealed that agricultural management (88%), wetland restoration/conservation (75%) and afforestation/reforestation (58%) were the preferred AFOLU sector adaptation activities whereas forest management (55%), bioenergy (62%) and afforestation/reforestation (78%) were proposed for mitigation. The implementation of these activities will depend on technical and financial resources as well as capacity building. The overlap of adaptation and mitigation AFOLU sector activities presents an opportunity to develop strategies and policy frameworks for synergy outcomes in Africa.

Keywords: AFOLU, climate change, adaptation, mitigation, Africa

Agriculture, foresterie et autres utilisations des terres dans les Contributions Déterminées au niveau National: perspectives pour l'Afrique

K. FOBISSIE, E. CHIA, K. ENONGENE et V.O. OEBA

Ce document avait pour but d'examiner de quelle manière les activités du secteur Agriculture, Foresterie et Autres utilisations des Terres (AFAT) et leurs contributions sont représentées dans les engagements des pays africains en matière de changement climatique après 2020 et d'évaluer les conditions nécessaires à la réussite de leur mise en œuvre. Des données secondaires sur les Contributions Déterminées au niveau National (CDNs) ont été collectées pour 52 pays africains, tandis que des données primaires ont été obtenues de Madagascar, de la République Démocratique du Congo, du Cameroun, de la Côte d'Ivoire et du Burkina Faso. Des approches qualitatives et quantitatives d'analyse des données ont été utilisées. L'étude a révélé que la gestion agricole (88%), la restauration / conservation des zones humides (75%) et le boisement / reboisement (58%) sont les activités d'adaptation préférentielles du secteur AFAT, tandis que la gestion forestière (55%), la bioénergie (62%) et le boisement / reboisement (78%) ont été proposés pour l'atténuation. La mise en œuvre de ces activités dépendra des ressources techniques et financières ainsi que du renforcement des capacités. Le croisement des activités d'adaptation et d'atténuation dans le secteur AFAT offre l'occasion d'élaborer des stratégies et des cadres politiques pour obtenir des résultats de synergie en Afrique.

La agricultura, la silvicultura y otros usos de la tierra en las Contribuciones Determinadas a Nivel Nacional: perspectivas para África

K. FOBISSIE, E. CHIA, K. ENONGENE y V.O. OEBA

El objetivo de este artículo fue estudiar la forma en que las actividades de la agricultura, silvicultura y otros usos de la tierra (AFOLU, por sus siglas en inglés) y sus contribuciones están representadas en los compromisos de los países africanos para después de 2020 en materia de cambio climático y evaluar las condiciones necesarias para una implementación satisfactoria. Se recopilaron datos secundarios sobre las Contribuciones Determinadas a Nivel Nacional en 52 países africanos y se obtuvieron datos primarios de Madagascar, la República Democrática del Congo, el Camerún, Côte d'Ivoire y Burkina Faso. Se utilizaron enfoques de análisis de datos cualitativos y cuantitativos. El estudio reveló que la gestión agrícola (88%), la restauración y conservación de humedales (75%) y la forestación y reforestación (58%) fueron las actividades de adaptación preferidas del sector AFOLU, mientras que la gestión forestal (55%), la bioenergía (62%) y la forestación y reforestación (78%) fueron propuestas como formas de mitigación. La implementación de estas actividades dependerá de los recursos técnicos y financieros, así como del fortalecimiento de capacidades. El solapamiento de algunas de las actividades de adaptación y mitigación del sector AFOLU ofrece una oportunidad para elaborar estrategias y marcos políticos con los que lograr sinergias en África.

INTRODUCTION

Human activities have caused about 1.0°C of global warming above pre-industrial levels and the impacts on natural and human systems are being felt (IPCC 2018). Different regions of the world are already experiencing an increase in: mean temperature, hot extremes, heavy precipitation, sea-level rise, recurrent droughts and precipitation deficits. In response, actions to reduce the negative impacts of climate-related risks are being taken by many countries. In December 2015, Parties to the United Nations Framework Convention on Climate Change (UNFCCC) successfully negotiated a new international climate agreement. The agreement was a breakthrough in international climate policy. The agreement had a multilateral dimension and enabled developed and developing countries to take action based on their national circumstances and a long-term goal. The common long-term goal was to keep the global temperature well below 2°C, while also making effort to stay below 1.5°C (UNFCCC 2016a). The agreement was the fruit of many years of negotiations under the UNFCCC, where a formal mandate was adopted to negotiate a new agreement in 2011 in Durban. Over the years, governments have portrayed their political momentum through their bilateral and multilateral networks and initiatives such as G7, G20, as well as the United States and China Joint Presidential Statement on Climate Change (White House 2016), to build agreements on critical issues prior to the finalization in Paris. Furthermore, significant momentum was created when countries, after the Conference of Parties (COP 20) meeting in Lima, started to formulate and submit individual national climate action plans in 2015. The national plans called Nationally Determined Contributions (NDCs), gave opportunities for the first time for many governments to formulate a complete vision for addressing climate change (Bodle *et al.* 2016). At the international level, the NDCs demonstrated the political will of governments and serve as an indication of their readiness to contribute to the global effort to combat climate change.

The NDCs were one of the building blocks of the Paris Agreement. NDCs equally represent the post-2020 global emissions reduction commitments of Parties to the UNFCCC (UNFCCC 2019). They link national policy frameworks i.e. governments determine their contributions in the context of their national circumstances, priorities and capabilities, to the global framework that drives the collective action towards a low-carbon and climate resilient future. The process gave countries the important means to communicate internationally, the steps they will take to address climate change in their respective countries. It reflected each country's ambition to reduce emissions taking into account national circumstances and capabilities. Some countries included how they will address the adaptation to climate change impacts and what support they need from or will provide to other countries to adopt low-carbon pathways and to build climate resilience.

In terms of emission reduction targets of the NDCs, there has been considerable progress compared to the "business as usual" scenarios that are dominated by increasing emissions. However, there is a gap between emission pathways that would result from current ambitions and plans, and a pathway that is consistent with a reasonable chance for limiting the rise in global average temperature to no more than 2°C above pre-industrial levels (Boyd *et al.* 2015). One of the strengths of the Paris Agreement is the fact that it recognized the gap in emission reductions and gave countries the ability and flexibility to increase their ambitions over time. In addition, there will be a periodic global stocktaking to assess collective evolution towards the objectives. The first stocktaking is slated for 2023. Thereafter, stocktaking follows every five years. Countries are expected to consider the outcome of the evaluations to update and improve their national plans.

Throughout the cycle, countries need to work hard to narrow the emission gap, such as finding the reliable ways of achieving higher emission reductions. In addition, countries will need to intensify efforts to increase investments and innovation in sectors that could help close the gap between intentions and the goal before and after 2030. One of such relevant sectors especially for countries in the tropics is the Agriculture, Forestry and Other Land Use (AFOLU) sector.

Globally, the total annual greenhouse gas (GHG) emissions, including from the AFOLU sector, reached a record high of 53.5 GtCO2e in 2017, an increase of 0.7 GtCO2e compared with 2016 and hence putting the world on a more difficult pathway to limiting global warming to below 2°C or 1.5°C (UNEP 2018). The AFOLU sector is responsible for about one quarter of anthropogenic GHG emissions and is therefore a very important sector to meet the emission targets of countries especially as indicated in the NDCs (Bustamante *et al*. 2014).

However, mitigation options in the sector are currently facing financial, institutional and technological barriers (Smith *et al*. 2014). Policies governing practices in this sector need to account for both effective mitigation and adaptation. This can help to orientate practices in AFOLU towards global sharing of innovative technologies for effective land use (Bustamante *et al.* 2014). It also offers an opportunity to pursue mitigation and adaptation jointly through AFOLU during the implementation of NDCs.

The AFOLU sector is relevant for African countries to step up their future emission reduction determinations and the fight against climate change in general. In Africa, the AFOLU sector is a major source of emissions (Wanyama *et al*. 2018), thus relevant for mitigation options. The AFOLU sector needs to adapt to the impacts of climate change, and the ecosystem, goods and services from the sector are important for enhancing the adaptive capacity of vulnerable peoples and for food security in the African continent. Furthermore, the AFOLU sector is a pillar for sustainable development and a driving force for the short and long-term economic emergence in many African countries.

Investments and innovations are relevant to make the AFOLU sector in Africa to contribute immensely to climate change mitigation and adaptation. In this perspective, a situational analysis of the relationship between the AFOLU sector and the NDCs of African countries in the context of future climate change response needs is appropriate to draw lessons that will inform and facilitate rapid decision making.

The objectives of this study were two fold, namely: (i) to examine how Agriculture, Forest and Other Land Use (AFOLU) activities and contributions are represented in post 2020 climate change commitments (NDCs) of African countries; and (ii) assess the necessary conditions for a successful implementation of AFOLU activities in the proposed commitments.

Importance of AFOLU for achieving climate change mitigation and adaptation in Africa

Agricultural aspects of the AFOLU sector is important for climate change mitigation in Africa. Overall, agriculture is a major source of the three principal GHGs: CO_2, CH_4 and N_2O (Wanyama *et al.* 2018). Agriculture systems can also serve as carbon sinks through sequestration into biomass products and soil organic matter (Johnson *et al*. 2007). The current trends in agriculture expansion in poorer nations of the world drives land clearing and soil organic matter destruction. If this is to continue, about 1 billion hectares of land will be cleared globally by 2050, with CO_2 equivalent GHG emissions reaching about 3 Gt y-1 (Tilman *et al*. 2011). According to Smith *et al.* (2014), the size and regional distribution of future mitigation potentials were difficult to estimate accurately because they depend on a number of inherently uncertain factors. Some of those factors include population growth, economic and technological development. Countries in the south of the Sahara constitute a greater proportion of the poorer countries of the world. Thus, agriculture improvement measures are relevant to minimize GHG emissions. This was demonstrated by the different practices African countries have put forward to improve both crop and animal agriculture practices as a contribution to limit global GHGs emissions. Some of them include, agroforestry, soil and water conservation, agricultural intensification, efficient use of nitrogen, and the development of traits and varieties that help to mitigate (Mbow *et al*. 2014, Lybbert and Sumner 2010, Nyong *et al.* 2007).

Africa has great potentials to contribute to global climate change mitigation through forest carbon emission reduction activities. Africa has vast degraded lands which are suitable for the development of forest carbon sinks through afforestation and reforestation (Jindal *et al.* 2008, Unruh 2008). Due to a mix of socio-political, financial and technical factors, Africa is yet to benefit from the global approach of incentivizing and motivating the creation of carbon sinks through the Kyoto Protocol Compliance markets (Jindal *et al*. 2008). Notwithstanding, relative progress has been made in the region especially in Eastern Africa (Uganda and Kenya) to develop and implement AR activities.

Deforestation and forest degradation are a major source of carbon emissions in Africa and in other developing countries. There is a need to reverse the trends in the rate of deforestation and forest degradation. The most important driver of deforestation is commercial agriculture, followed by subsistence agriculture. Degradation is mostly driven by timber exploitation, followed by fuelwood collection and charcoal production, uncontrolled fire and livestock grazing (Noriko *et al*. 2012). The Paris Agreement underscored the importance of forests as sinks and sources of GHG emissions. REDD+ is one of the approaches to respond to this call jointly agreed to by all the 195 members of the UNFCCC. If well designed and implemented, the REDD+ approach will not only help Africa participate in achieving the global climate change mitigation objective but will also lead to the non-carbon benefits that will make contributions to climate change adaptation. However, some argued that linking REDD+ and NDCs should be treated with care, because overlapping REDD+ into NDCs may undermine and undercut the fundamental principles of REDD+ as a mechanism that rewards countries for keeping their trees standing (Kalame and Nkem 2015).

Bio-energy within the AFOLU sector can make African countries contribute to global ambitions to mitigate climate change. Generally, bioenergy has a major role to play in climate change mitigation, but there are concerns to consider such as the sustainability of practices and the efficiency of bioenergy systems (Smith *et al*. 2014). Africa is spatially suitable for hosting the production of bioenergy crops. However, on large-scale, serious threats may arise in relation to food security, water resources conservation, biodiversity conservation and livelihoods. It should be noted that the role of bioenergy crops in GHG emission is still under debate related to land use competition effects, despite increasing number of bioenergy crop plantations in the different regions of Africa. In sub-Saharan Africa, energy consumption is comprised of 80% biomass (Zulu and Richardson 2013). Thus, the biomass sector provides an important opportunity for climate change mitigation in Africa. Examples of mitigation actions may include improved charcoal and fuelwood stoves and small-scale biogas production (Hofstad *et al*. 2009).

Adaptation of agriculture systems to climate change is a concern and a priority for many African countries. In many parts of Africa, the impacts of climate change i.e. increasing temperature and changes in precipitation are expected to be unfavourable for crop and livestock production. There is emerging evidence that high-value perennial crops could also be adversely affected by temperature rise, in addition to increased pressure on crops from pest, weed and diseases (Field *et al.* 2014). Generally, warming and drying may reduce crop yields by 10–20% in the long-term, though losses in some places would be probably more severe (Jones and Thornton 2009). This is coupled with the fact that rain-fed agriculture is the dominant source of staple food production and livelihood base of the bulk of the rural poor in Africa (Cooper *et al.* 2008). In the short-term, changes are also expected. For example, there will be changes in the frequency and harshness of extreme climate events and this will have significant consequences for food production, food security and livelihoods. Increasing frequencies of heat stress, drought and flooding events are likely and these will undoubtedly have adverse effects on crop and livestock productivity (Parry 2007). In this light, there is an urgent need to accelerate investments through innovations that have high chances of succeeding economically and of being adopted with solid impacts, even above and beyond that requested by African countries in their NDCs.

Climate change will exert significant pressure on forests ecosystems and their provision of ecosystem goods and services which form safety nets for millions of rural poor in Africa (Somorin 2010). Building adaptation strategies is imperative for forest-dependent households and communities, and countries whose economies are dependent on forest and forest related sectors. Climate change can have effects on the mitigation potentials of forests. Rising temperatures, droughts, fires, insect and disease outbreaks exacerbated by climate change and climate extreme may lead to forests becoming a weaker sink for carbon, thereby putting the mitigation potential of forests at risk (Smith *et al.* 2014). Designing and implementing forest management strategies for the adaptation of forests is important to keep carbon in trees and to increase the sequestration potentials of forests and trees.

Adaptation of coastal, wetlands and ocean systems is pertinent for African countries. These systems contribute to the economies and livelihoods of African countries (Rebelo *et al.* 2010, Schuyt 2005). Coastal systems will experience impacts through sea level rise and storm sells. Coral reefs and coastal upwelling that are important for fisheries in Africa will be affected by climate change through ocean acidification and sea surface temperature rise (Field *et al*. 2014). On the mitigation side, there is growing evidence that mangrove forest systems can contribute to the mitigation of climate change through their capacity to provide ecosystem services, including carbon storage (Nam *et al.* 2015, Bhomia *et al*. 2016). This is a reason for African countries with coastal or mangrove forests systems to support conservation and restoration in order to benefit from carbon offset payments under approved climate change mitigation strategies and actions.

METHODOLOGY

Overview of different categories of AFOLU activities

This study combined the voluntary carbon standards (VCS) AFOLU categories with those proposed by the AFOLU low emission development strategies (AFOLU LEDS) working group (Zeleke *et al*. 2016). Six categories of AFOLU activities emerged from the combination, used in the collection and analysis of data from various NDC documents. Table 1 highlights the different categories used for this study to cover both mitigation and adaptation aspects of AFOLU (Table 1).

Data collection and procedure

Secondary data was used for this study and was drawn from the NDCs submitted by African countries to the UNFCCC secretariat in 2015 (UNFCC 2016b). These countries were Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic (CAR), Chad, Comoros, Democratic Republic of Congo (DRC), Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Republic of Congo, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Republic of Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zambia, and Zimbabwe. Out of the 54 African countries, 53 submitted their NDCs. Libya was the only country that did not elaborate and submit their NDC probably due to political instability. While all the submitted NDCs were in either English or French language, the NDC of Equatorial Guinea was in Spanish, which was excluded from this study.

The secondary data on AFOLU related contributions to NDCs was accessed from UNFCCC Secretariat website in February and March 2016 following three key steps to capture relevant references and appearances. Firstly, six different categories of AFOLU activities as indicated in Table 1 were predefined consisting of afforestation, reforestation (AR); agricultural management (AM); forest management (FM); avoidance of deforestation and degradation (DD); bio-energy (BE); and wetland restoration and conservation (WRC).

TABLE 1 Different categories of AFOLU activities (Source: VCS and Zeleke *et al*. 2016)

Category	Examples
Afforestation and reforestation (AR)	Agroforestry, tree planting, revegetation, drought-resistant forest species, national reforestation programs, assisted and natural regeneration
Agriculture management (AM)	crop, soil and livestock management activities, climate smart agriculture, conservation agriculture, use of adapted seed varieties, agricultural intensification, soil conservation
Forest management (FM)	Sustainable/improve forest management, fire management, ecosystem resilience activities, land management plans, reduced impact logging, certified logging (FLEGT, FSC), Community forest management
Deforestation and degradation avoidance (DD)	Activities to reduce deforestation and forest and land degradation by fighting desertification, better management of pastoralism, forest protection and conservation, management of protected areas and national parks, dune fixation
Bio-energy (BE)	Energy crops, solid waste, liquid waste, biogas, residues, improve firewood and charcoal stoves
Wetland restoration and conservation (WRC)	Protection and conservation of river basins, lakes, watersheds, coastal adaptation, mangrove conservation, coastal zone management

Secondly, references to the predefined AFOLU categories within the mitigation and adaptation contribution sections of the NDCs were identified and analysed. Thirdly, different requirements and means of implementing AFOLU activities within the NDCs were mapped out.

Data Analysis

The data was analysed using both qualitative and quantitative statistics. Yoshikoder and Word scores softwares were used for the analysis of the data. *Yoshikoder* is an open-source computer-assisted software for performing quantitative content analysis (Lowe 2006, Chen 2011). Both computer software were created as programmes for extracting policy positions in policy document.

Using *Yoshikoder*, the AFOLU categories and patterns of words of interest were pre-determined, and then examined how these keywords are distributed in the NDC documents. In order to be able to analyse the text using *Yoshikoder*, the format of NDC documents was changed from Word and PDF formats to a text format. Key words including forestry, agriculture, finance, capacity and technology were used to run the analysis. Each keyword was further expanded to capture the full range of words that have the same or similar meaning. For example, to search for "agriculture" in the NDC documents, other similar words such as farm, crop, livestock, and soil were used. In some cases, truncated words were used in the search. In the case of forestry words such as forests, reforestation, afforestation, forestry, forest management, protection, conservation, and sector were used. To ensure that the results from *Yoshikoder* were reliable, a hand-coded search for a few key words were conducted and the results of the frequencies were similar. To further analyse, the meanings associated with the use of keywords in the NDC documents, a concordance of the keywords and brief 5-word explanation for each keyword in the NDC documents were made. In some case, where relevant, one sample chi square test was conducted to see if there were differences between the observed and the expected frequencies or values of keywords.

RESULTS

Integration of AFOLU in African NDCs

AFOLU Categories in the NDCs

The study, as indicated in Figure 1, revealed that 88% (46 out of 52) of the countries referenced agricultural management (AM) followed by wetland restoration/conservation (WRC) as contributors to climate change adaptation. The bio-energy (BE) category was least referenced by countries in the AFOLU based adaptation activities. On mitigation, the afforestation and reforestation were referenced by 77% of the countries as the AFOLU category that contributes to mitigation followed by bio-energy (61%). The wetland restoration and conservation (WRC) category was referenced by only 10% of the countries as a contributor to climate change mitigation (Figure 1). Overall, there was a limited commitment in the African region on the role of coastal systems like mangrove forest systems in carbon storage.

AFOLU Categories across different African Regions

The sub regional analysis, namely, Central, Southern, Eastern, West and North Africa showed that afforestation and reforestation (AR) category was the most referenced by the NDCs of the countries in terms of its role in mitigation,

FIGURE 1 *Reference of agriculture, forestry and other land uses (AFOLU) in the nationally determined contributions (NDCs) of African countries*

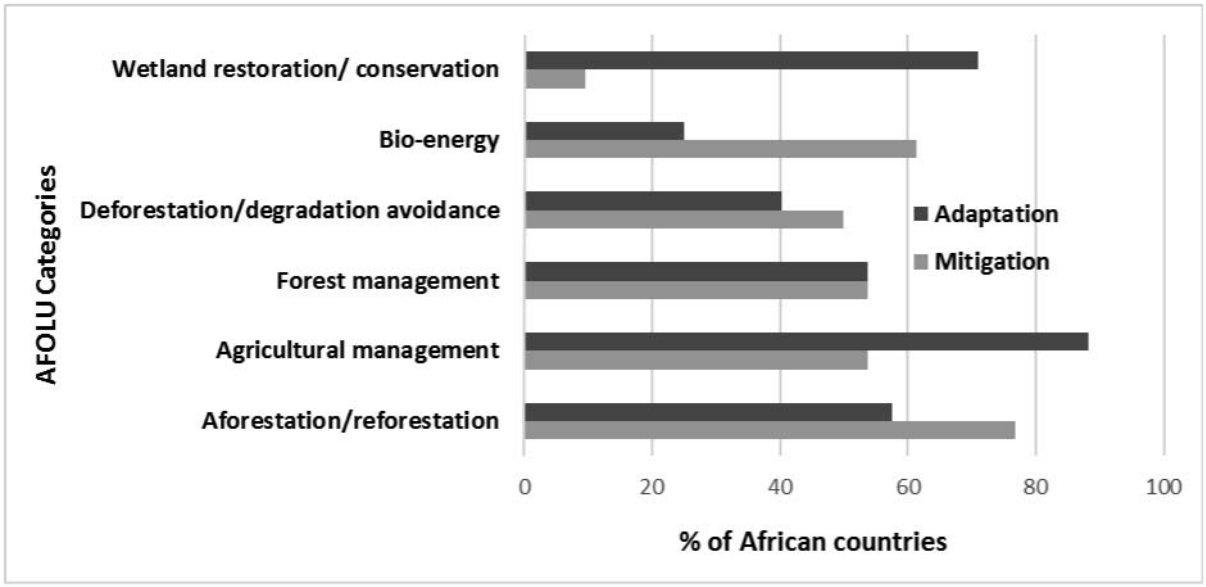
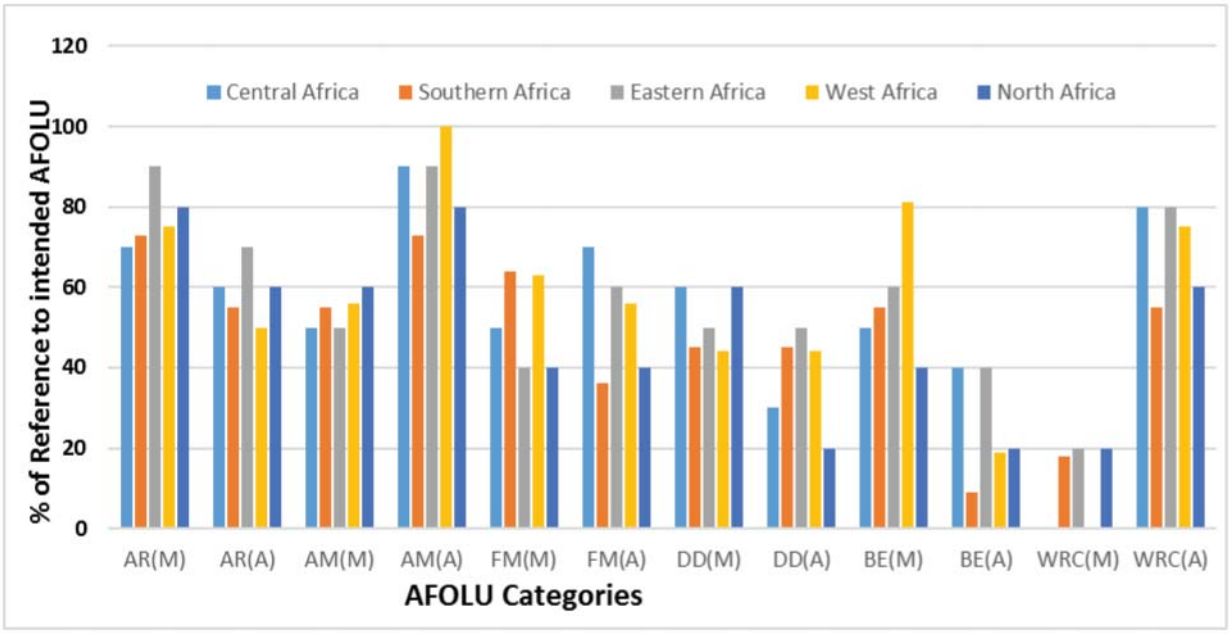


FIGURE 2 *AFOLU activities in the NDCs of different regions of Africa*



Note: (M) represents mitigation actions while (A) represents adaptation actions

followed by bio-energy (BE), deforestation and degradation avoidance (DD) and agricultural management (AM). This implies that AR activities were appealing to all the regions. For example, 90% of Eastern African countries referenced AR as a major activity for mitigation. The AM category was the most referenced in the adaptation contribution section of the NDCs of the countries when grouped together according to regions, followed by wetland restoration and conservation (WRC), and AR. In West Africa, BE category of activities appeared to be important for mitigation. It was referenced by 81% of the NDCs of the countries in the region. The AM activity of the AFOLU sector was referenced by 60% of countries grouped by regions, as important for climate change adaptation. West African countries scored the highest (100%) in terms of referencing agriculture management activities in their NDCs as important for adaptation (Figure 2).

AFOLU Categories in different African forests

Our analysis presents the contribution of the AFOLU sector in mitigation and adaptation in the dry forest, rain forest, and Mediterranean forests types. The rational for highlighting different forest types is explained by the different characteristics and potentials of forests that are related to the sequestration of carbon, vulnerability to climate risks and the different forest ecosystems services used by vulnerable forest-dependent communities. The NDCs of 92% of dry forests countries mentioned AR activities as relevant for mitigation of climate change (Figure 3). This was followed by the NDCs of Mediterranean forest countries (80%). The AM activities were mentioned by the NDCs of rainforest and dry forest countries (i.e. 92% each) as important for making contributions to climate change adaptation.

Conditions and determinants for implementation of AFOLU activities

All sampled African countries will meet their mitigation and adaptation commitments as indicated in their NDCs on the conditions that they are provided with adequate means of implementation in terms of capacity building, technological support and financial resources. However, 90% of these African countries were prepared to use their own resources to implement some of the actions indicated in their NDCs. This is referred to as the unconditional contributions of African countries with no financial assistance required. On the other hand, many African countries are expecting about 70% of external financial support to be able to implement the prioritized activities indicated in their respective NDCs. This is referred to as conditional contributions. The African countries stressed the need for the different implementation support in similar (Table 2) and in different frequencies. However, the difference between the two was random with pretty high probability of about 30.9 % (with error).

African countries in their NDCs stressed finance and technology transfer with equal frequency (Table 4). There was a less than 1% probability that the reference to finance and capacity building in the NDC documents can be explained by a random process. African countries in a systematic way really intended to emphasize the importance of having finance for the successful implementation of their mitigation and adaptation contributions to address climate change. The private sector has a major role to play in the implementation of the activities of the NDCs. Many countries indicated the building of partnerships between the public and the private sector at the national and international levels in order to mobilise financial resources.

FIGURE 3 *AFOLU activities in the NDCs across different forest types*

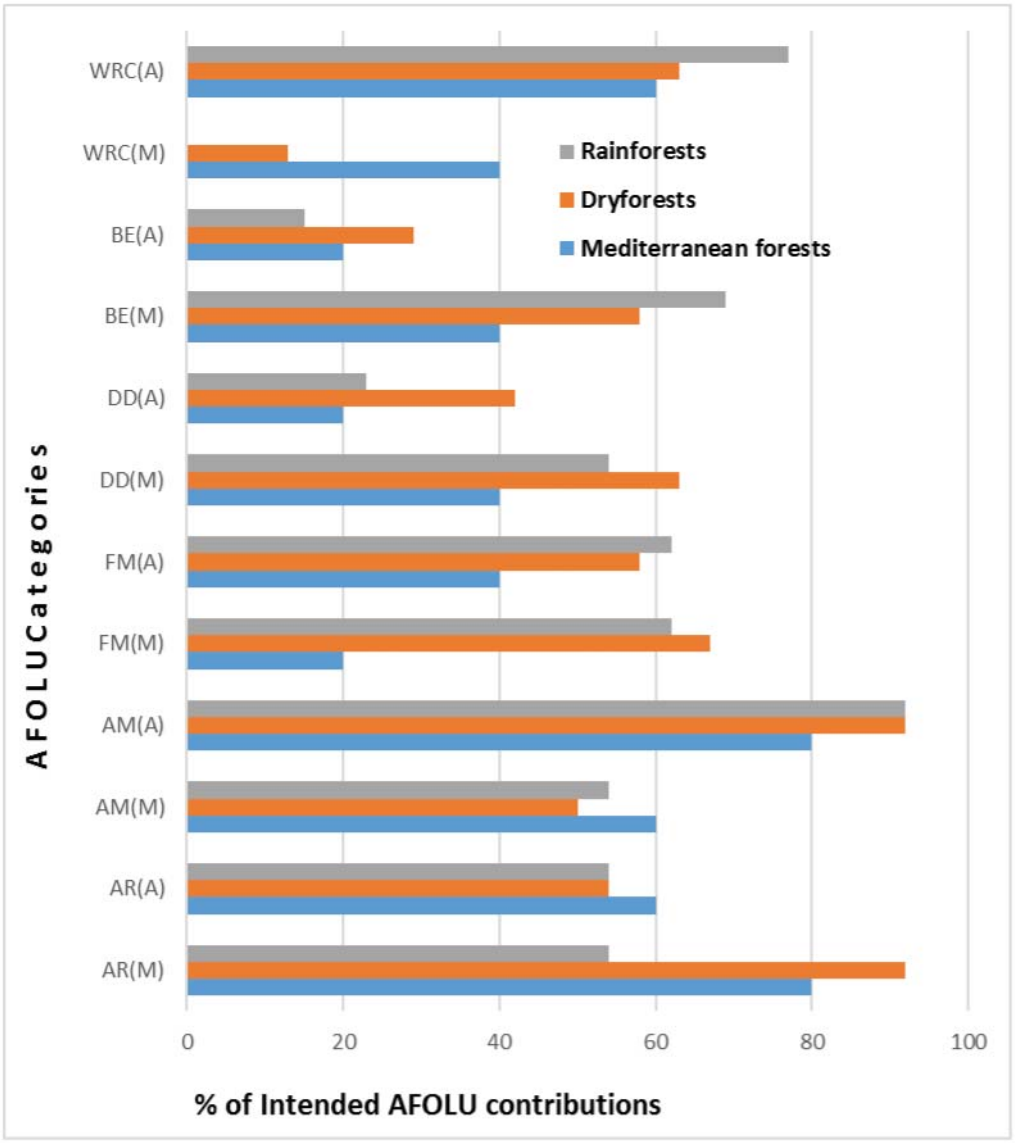


TABLE 2 *Request for means of implementation by African countries*

Means of Implementation	Frequency in text	Reference to mitigation		Reference to adaptation	
		No. of countries	%	No. of countries	%
Capacity building	755	41	79	46	88
Transfer of technology	536	43	83	44	84
Finance	904	52	100	51	98

DISCUSSION

Synergetic adaptation and mitigation outcomes in AFOLU activities

Synergy refers to the "intersection of adaptation and mitigation so that their combined effect is greater than the sum effect if implemented separately" (IPCC 2007). The synergy between mitigation and adaptation (M+A) in AFOLU is about implementing activities in a way that they deliver simultaneous positive outcomes for M+A (Chia *et al.* 2016). The AFOLU sector in Africa is faced with two important challenges. Firstly, the sector which is vulnerable to climate change which is responsible for food security, poverty alleviation and development in Africa. Secondly, AFOLU is a critical component in Africa's contribution to the global climate change solution. This is an indication that both mitigation and adaptation are priorities for Africa. Activities in the

AFOLU sector are designed and implemented independently or in combination in landscapes to respond to adaptation or mitigation. In the emerging literature on M+A synergy, it is argued that due to the overlap between mitigation and adaptation measures, where interventions can have both mitigation and adaptation benefits, implementing them in an integrated manner will be more efficient and effective (Dang *et al*. 2003, Matocha *et al.* 2012). The analysis of the NDCs indicates that many African countries were aware of the linkages between mitigation and adaptation where they noted that mitigation can produce co-benefits for adaptation and vice-versa.

M+A synergy outcomes are only a part of the expectations from landscapes, which is faced with other demanding functions such as food security, poverty reduction, energy and biodiversity conservation. In this context, synergy in the case of the AFOLU sector should be looked from a landscape system approach where M+A are considered as part of a broader number of multiple landscape functions which are delivered by a set of practices (Duguma *et al.* 2014). Some African countries in their NDCs mentioned, though not substantial, the implementation of activities in integrated ways at the landscape level.

The "climate smart-landscapes" approach provides opportunities to enhance the integrated method to synergy by providing a land use planning process that effectively engage different stakeholders and their priorities (Fobissie 2015). Through this approach, important synergies for agriculture production, climate M+A as well as other livelihood and environmental benefits can be generated, through coordinated actions at farm and landscape scales. However, a number of institutional instruments are required to enhance this approach such as multi-stakeholder or multi-sector planning, supportive governance and tenure, spatial targeting of investments and a strong system to monitor social and ecological changes at the different levels. Therefore, putting these instruments into place will require a higher level of political, institutional and technical support (Scherr *et al.* 2012).

African countries in their NDCs stressed the need to have financial, capacity building and technological support to carry out full scale implementation of activities in the NDCs. However, it should be noted that the availability of these resources for implementation is not enough. They should be accompanied by an enabling environment from the local, national and global levels to facilitate the efficient and effective use of these resources in order to achieve the desired outcomes for M+A. Furthermore, sufficient detail, clear and transparent financial, technological and capacity building needs should be included in the NDCs, when countries are doing revision or updating. The revised NDCs will contribute in building the public-private partnerships that African countries are hoping to use to mobilize the required resources for NDC implementation.

Prospects for regionally designed NDC interventions

Ecologically and in terms of geography, it is easy for countries in a region to perceive a clear picture of a regional approach to design NDC interventions. However, in terms of strategy and means of implementation of the interventions, caution needs to be applied. This is because countries in a region may have the same geographical setting to respond to climate change, but may possess different circumstances and priorities at the national level. Countries possess different levels of economic and technological development and different poverty levels. Countries may also have different ways of behavioural change which is influenced by cultural and normative backgrounds, market structures and incentives, and how all these translate into the demand for food, fibre, fodder and fuel as well as development in agriculture, fisheries and forestry sectors. Other factors that may also lead to differentiation include climate change impacts on agriculture and other natural systems and adaptive capacity (Smith *et al.* 2014). Though, a geographical region may experience the same type of climate change impacts, for example, West Africa and the Sahel, the countries in this region may have different levels of resources to define adaptation interventions.

Experience from ongoing global mechanisms and processes on M+A, shows that regional links are required and should be created on some aspects. For example, promoting regional efforts to pull resources, knowledge and skills on technical aspects of NDC interventions related to AFOLU.

Reference was made 175 times to the six AFOLU categories for adaptation compared to 159 times for mitigation. The study showed that there was about 38% probability ($p = 0.38$) that the difference in reference to AFOLU activities under mitigation and adaptation contributions in the NDC documents can be explained by a random process. A probable explanation was the view point of seeing mitigation activities and initiatives as a window of opportunity to transform to a low-carbon emission development path. This can be corroborated by the fact that some regions such as Central Africa as well as individual countries were already putting green economy policy programs in place (Enongene and Fobissie 2016).

Agriculture

The NDCs of African countries underscore country priorities to determine and address mitigation and adaptation in the agriculture and livestock sub-sector at the national level. The sub-sector was referenced by about 54% of the NDCs of African countries as relevant for GHG emission reduction. The main sources of GHG emissions generally mentioned here included enteric fermentation, manure management, onsite burning of agricultural residues, agricultural soils, use of fertilizers and rice growing. Interventions to meet their targets in this sector strongly depended on international financial support and capacity building. However, to access financial resources, countries may be required to be able to demonstrate strong methodologies in measuring, reporting and verifying emissions from this sector. Thus, in their future revision and updated NDCs, African countries are encouraged to improve on clarity regarding technological and capacity building needs in reducing emissions from agriculture. The technological and capacity building request from African countries to improve agriculture for climate change adaptation should be accompanied by enabling conditions that

would facilitate uptake, knowledge management and transfer. Improving agricultural systems for mitigation and adaptation is an opportunity to reduce pressure on other resources such as forest; especially in countries where conservation of intact forest is important for its national contributions.

Forestry

Forests are included in the mitigation and adaptation sections of almost all the NDCs analysed in the study. This is an indication that the forestry sector is important within their NDCs as each of the countries established one or more goals in the forestry sector. The reviewed NDCs indicated that afforestation and reforestation (AR) activities are the activities that are commonly employed by many countries to mitigate climate change. The high reference of the AR as a major contributor to carbon emissions abatement in the NDCs, was a sign that many countries were making more efforts to restore degraded lands as compared to efforts to conserve and sustainably manage existing forests and standing trees. African countries were also interested to reduce emissions through conservation efforts like the reduced emissions from deforestation and forest degradation approach.

The implementation of the forestry interventions that would enable African countries make contributions to curb GHG emissions are strongly conditioned by the availability of external financial and technological supports. Presently, mitigation finance falls short of what is needed to deliver ambitious targets. Our analyses of the NDCs show that the total estimated international finance requirements for Ghana, Niger, Central African Republic, Chad, and Morocco were US$7.61 billion, US$968 million, US$1.2 billion, US$50 million, and US$35 billion, respectively. Furthermore, African countries are not performing well in terms of generating sufficient financial returns from the Kyoto Protocol compliance market on CDM AR CERs sales. African countries should be prepared to influence future international negotiations to come up with favourable conditions that will enable the forestry sector to realize its potentials to contribute to emission reduction through the implementation of NDCs.

In the absence of external financial support, African countries still have the opportunity to make contributions through their ongoing forestry and environmental activities to rehabilitate and restore degraded lands. This has potentials for carbon sequestration and for climate change adaptation through the provision of ecosystem goods and services from forests and trees. Many of such initiatives are found in the Sahel of West Africa, Eastern and Central Africa (Fobissie and Nkem 2015).

The determination of forestry in the NDCs of many African countries will be confronted by the political-economy of the forestry sector. Forestry sector has a major role to play in the social and economic development of many African countries. The ability to keep forests standing is trapped between the interests of other sectors such as mining, infrastructure, commercial agriculture and logging that are responsible for the "business as usual" scenario of carbon emissions from the forestry sector. Transformational change such as changes in economic interests, discursive practices and power relations, is needed to change the course of sectoral drivers of deforestation and forest degradation (Murdiyarso *et al*. 2012). In this context, to set high targets for forestry sector emission reduction approaches such as REDD+ in the NDCs, African countries need to understand whether they possess sufficient incentives and capacity to initiate and facilitate transformational change.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This paper has examined the AFOLU sector in the NDCs of African countries in the context of its activities, role and implementation challenges and opportunities. The AFOLU sector intervention and activities were well represented in the adaptation and mitigation contributions as communicated by the NDCs of African countries. The AFOLU sector is a key contributor to GHG emissions in Africa. The sector is already experiencing the impacts of climate change throughout the different regions of the continent. Furthermore, the sector is relevant for food security, poverty alleviation and national development for many countries in the continent. While the NDCs clearly stressed the need for financial support, technology transfer and capacity building assistance in order to implement and meet all or part of their intended contributions, details were lacking in a good number of the NDC documents. Some NDCs specified their contributions in terms of conditional and unconditional depending on the availability or provision of support, mainly financial.

Recommendations

In order for the AFOLU sector in Africa to reach its full mitigation potentials that will contribute to any successful climate change response ambition, there is need to look for ways to strengthen and improve the performance of the AFOLU sector. It was evident from the study that there is a significant overlap between M+A interventions in the NDCs of African countries in relation to the AFOLU sector. This is an important opportunity for African countries to re-organize M+A processes in their respective strategies and policy frameworks for synergy outcomes. For example, in the adaptation strategies and plans, priority should be given to adaptation activities that exhibit the potentials to deliver mitigation benefits, and vice-versa. The following can therefore be considered in the implementation of AFOLU based NDCs activities:

- Climate change M+A is only a part of the multiple expectations from the AFOLU sector in Africa. The Climate-Smart Landscape approach will provide an opportunity for AFOLU to respond to M+A and also supports other functions like food security, poverty alleviation, biodiversity conservation and energy;

- The landscape approach scenarios in Africa have a complex relationship between the AFOLU sub-sectors and therefore would require a high level of political, institutional and technical supports to facilitate and support coordination, multi-stakeholder planning, governance arrangements and investment flows;
- In many African countries, complex political economy situations drive competition between sectoral policies and interests. This calls for transformational change to achieve any meaningful emission reductions from the AFOLU sector. Governments, following their national contribution pledges should be able to initiate and facilitate transformational change i.e. changing from the "business as usual" conditions through changes in economic interests and power relations; and
- There is an urgent need for climate change action in all the sub-sectors of the AFOLU group of sectors in Africa. To achieve results in an efficient and effective manner, it is important to break the sectoral barriers between agriculture and forestry through a holistic and cross-cutting approach when fixing emission reduction targets.

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An evaluation of determinants affecting design and implementation of CDM and REDD+ in Africa

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SUMMARY

The Clean Development Mechanism (CDM) and Reducing Emissions from Deforestation and forest Degradation (REDD+) are important global processes negotiated under the United Nations Framework Convention on Climate Change (UNFCCC) to mitigate climate change through emission reduction. These processes have provided Annex I and non-annex I countries with an opportunity to reduce their emissions through the forestry sector and other nationally determined contributions. It is in this context that forest based CDM and REDD+ projects have been initiated in Africa. However, the progress made on designing and implementation of such projects has been slow. This study sought to evaluate determinants affecting design and implementation of CDM and REDD+ in Africa. The study employed primary and secondary data collection methods. The design and implementation of CDM was greatly influenced by correct understanding on how CDM operates, meaningful utilization of a country's sovereign rights, going beyond generic goals agreed in Kyoto Protocol and utilising underlying goals to continuously build systems and capacity. For REDD+, financial support, equitable benefit sharing mechanisms, education, training, research and gender consideration were important determinants. Overall, for both CDM and REDD+ to thrive well in Africa, capacity building in terms of technical skills, technology and financing remain fundamental.

Keywords: determinants, capacity building, CDM, REDD+, Africa

Evaluation des déterminants affectant la conception et la mise en œuvre du MDP et de la REDD + en Afrique

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Le Mécanisme de Développement Propre (MDP) et la Réduction des Emissions dues à la Déforestation et à la Dégradation des forêts (REDD+) sont des processus mondiaux importants négociés dans le cadre de la Convention-cadre des Nations Unies sur les changements climatiques (CCNUCC) avec pour but d'atténuer les effets du changement climatique à travers la réduction des émissions des gaz à effet de serre. Ces processus ont fourni aux pays listés et non-listés à l'Annexe I de ladite convention l'occasion de réduire leurs émissions par le biais du secteur forestier et d'autres contributions déterminées au niveau national. C'est dans ce contexte que des projets de MDP et de REDD+ basés sur les forêts ont été initiés en Afrique. Cependant, les progrès réalisés dans la conception et la mise en œuvre de tels projets en Afrique ont été jugés lents. Cette étude visait à évaluer les déterminants affectant la conception et la mise en œuvre des projets MDP et REDD+ en Afrique. L'étude a utilisé des méthodes de collecte de données primaires et secondaires. La conception et la mise en œuvre des projets MDP ont été grandement influencées par une bonne compréhension du mode de fonctionnement dudit mécanisme, une exploitation judicieuse des droits souverains des pays, allant au-delà des objectifs génériques convenus dans le Protocole de Kyoto et utilisant les objectifs sous-jacents pour renforcer en permanence les systèmes et les capacités. Pour la REDD+, le soutien financier, les mécanismes de partage équitable des avantages, l'éducation, la formation, la recherche et la prise en compte du genre étaient des déterminants importants. Globalement, pour que le MDP et la REDD+ prospèrent bien en Afrique, le renforcement des capacités en termes de compétences techniques, de technologie et de financement reste fondamental.

Evaluación de los determinantes que afectan el diseño y la implementación del MDL y REDD+ en África

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El Mecanismo de Desarrollo Limpio (MDL) y la Reducción de Emisiones de la Deforestación y Degradación de Bosques (REDD+) son procesos globales importantes negociados bajo la Convención Marco de las Naciones Unidas sobre el Cambio Climático (CMNUCC) con el fin de mitigar el cambio climático a través de la reducción de emisiones. Estos procesos han brindado a los países incluidos en el Anexo I (y a los no incluidos) la oportunidad de reducir sus emisiones a través del sector forestal y de otras contribuciones determinadas a nivel nacional.

Es en este contexto que se han iniciado proyectos forestales del MDL y de REDD+ en África. Sin embargo, los avances logrados en el diseño y la ejecución de esos proyectos en África han sido lentos. Este estudio buscó evaluar los determinantes que afectan el diseño e implementación del MDL y de REDD+ en África. El estudio empleó métodos de recolección de datos primarios y secundarios. El diseño y la implementación del MDL estuvieron muy influenciados por la correcta comprensión de cómo funciona el MDL, la utilización significativa de los derechos soberanos de un país, el ir más allá de los objetivos genéricos acordados en el Protocolo de Kioto y la utilización de objetivos subyacentes para desarrollar continuamente sistemas y capacidades. Para REDD+, el apoyo financiero, los mecanismos de distribución equitativa de beneficios, la educación, la formación, la investigación y la atención al género fueron determinantes importantes. En general, para que tanto el MDL como REDD+ prosperen en África, el desarrollo de capacidades en términos de conocimientos técnicos, tecnología y financiación sigue siendo fundamental.

INTRODUCTION

The Clean Development Mechanism (CDM) was established to draw developing and Annex I countries into development cooperation through carbon offset projects (FCCC 1997). Before CDM, African countries practiced afforestation and reforestation (A/R) as part of their silviculture practices (McClellan 2004). These practices of A/R served the purpose of increasing forest cover and restoring degraded and deforested areas. Irrespective of the format it took, A/R always fulfilled carbon absorption and storage functions. However, when African countries expressed goals for supporting CDM projects, these goals were diametrically opposite to the continent's development needs. The goals pursued by Africa in implementing CDM projects differed from the underlying reasons with which the continent justified its actions (Hardcastle *et al*. 2010). African countries knew well that CDM-A/R had no safeguards that ensured communities' access to benefits. Few countries like Kenya, Uganda, South Africa, Morocco, Egypt and Nigeria engaged with good knowledge in implementing CDM projects (Fenhann 2016). Kenya, for instance, had 24 CDM projects that traded credits in CDM and Voluntary carbon markets (Hamrick and Goldstein 2016), while Tanzania had four CDM projects, Zambia like Ethiopia and Nigeria each had (3) CDM projects.

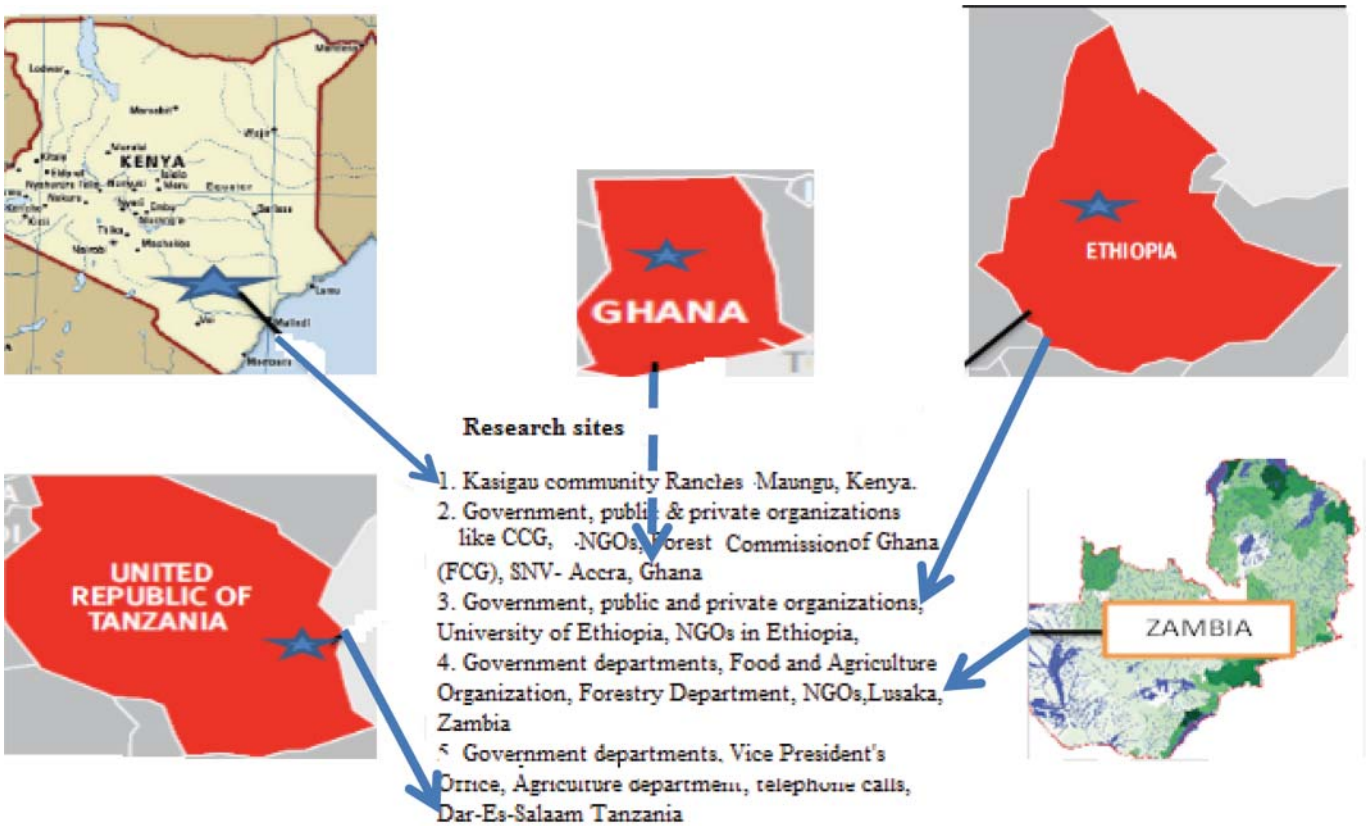
In general terms, the participation of African countries in CDM has been explained by the continent's desire to access development support through financing, transfer of technology and capacity building (FCCC 2001). For example, in 2016, a total of 8508 CDM projects were in the pipeline out of which 200 were in Africa, representing 2.3% of the global projects. Of the 200, 22 were in Kenya (Fenhann 2016). This showed that Africa remained underrepresented on global CDM projects. The challenges enumerated that resulted in this slow pace of CDM projects include but are not limited to: high dependence on external support, inadequate knowledge on carbon market operations, poor marketing of Certified Emissions Reductions (CERs) and Verified Emissions Reduction (VERs), inadequately developed procedures and systems to attract flow of financing from Annex I countries and entities towards CDM projects, inadequate capacity in resident technocrats to collaborate with foreign consultants, and inadequate technical competencies and knowledge to prepare and ensure effective implementation of CDM projects. These factors discouraged Annex I countries from collaborating with non-Annex I parties, resulting into increased costs of doing business in Africa.

The REDD+ mechanism was established to reduce emissions from deforestation and forest degradation through sustainable management of forests, conservation of forest carbon stocks and enhancement of forest carbon. According to the United Nations records, Reducing Emissions from Deforestation (RED) started in 2005 (FCCC 2005). After being piloted for close to 10 years, during which time methodological issues were elaborated RED had transitioned through REDD to REDD+ which was finally endorsed at the 2015 UNFCCC conference in Paris. Main methodological methods that were elaborated included: (i) standards for measuring, reporting and verification (MRV) of carbon emission reduction; (ii) preparation of national forest monitoring systems (NFMS); (iii) formulation of national REDD+ strategies with forest reference emission levels (FRELs) and reference Emissions levels (RELs); and (iv) providing forest definitions.

The policies and measures for REDD+ have been provided through REDD+ safeguards. Equally, the Warsaw conference addressed the following in regard to the phases (readiness, implementation and investment) of designing and implementing REDD+: results-based finance, coordination of support for implementation, modalities for national forest monitoring systems, presenting information on safeguards, technical assessment of reference (emission) levels, modalities for measuring, reporting and verifying (MRV), and information on addressing the drivers of deforestation and forest degradation (FCCC 2013). Finally, the Paris Conference endorsed REDD+ as a mechanism under the United Nations Framework Convention on Climate Change (IISD 2015).

In Africa the trend of designing and implementing CDM and REDD+ is not impressive. There are few pockets of projects on REDD+ mainly on pilot mode whereas very few are in place on AR CDM. This study therefore evaluated determinants affecting design and implementation of CDM and REDD+ projects in Africa with a view to informing policy makers and stakeholders in African forestry to seize the opportunities from climate financing to support the forestry sector for sustainable development in the continent. This was motivated by the expectation that knowledge of success and failure factors in design and implementation of CDM and REDD+ projects would provide decision makers with frameworks for making rational policy decisions.

FIGURE 1 *Study areas - Kenya, Ghana, Ethiopia, The United Republic of Tanzania and Zambia*



Source: Authors, 2017

Knowledge of positive factors on CDM and REDD+ projects would certainly enhance selection of project options that would improve the forestry sector performance and contribute to sustainable development in the continent.

MATERIALS AND METHODS

Study areas

This study was conducted in Ethiopia, Ghana, Kenya, Tanzania and Zambia (Figure 1), from March to May 2016. Selection of study area was based on availability of information on piloting and implementation of CDM and REDD+ projects.

DATA COLLECTION

Primary data was collected through in-depth discussions with experts in selected government agencies, the private sector, NGOs and communities. Field surveys were mainly used to collect data from activity sites to augment data and information gathered from in-depth discussions. To complete the last loop of the data collection, purposive sampling was also used. Twenty-five experts on climate change (CC) were selected and provided with structured electronic questionnaires. Secondary data was collected mainly from the United Nations (UN) published documents and web-based literature sources on CDM and REDD+ submitted by African countries to the UNFCCC, UNREDD-Desk, Forest Carbon Partnership Facility (FCPF).

DATA ANALYSIS

Qualitative content analysis was used to analyze CDM projects while strengths, weaknesses, opportunities and threats (SWOT) analysis was applied for REDD+ based projects. The data analysis involved evaluating underlying meanings of statements expressed during in-depth discussions held with experts, against official statements expressed in UN-documents and CDM country project records. The resulting data were used to generate codes, categories and themes to evaluate successes and failures of CDM projects in Africa. In this regard, four codes were generated from records, namely: (i) transfer of technology; (ii) capacity building; (iii) financing; and (iv) marketing of certified emission reduction (CERs) and verified emission reductions (VERs). In addition, three categories were deductively generated: (i) externally supported development; (ii) development through prudent production and marketing; and (iii) improved flow of financing from Annex I countries and entities due to resident capacity. Lastly, four themes were also deductively generated: (i) growth/trends of CDM projects in Africa; (ii) factors influencing successful cases of CDM implementation in Africa (iii) factors influencing low level of CDM projects implementation

in Africa; and (iv) contribution of CDM projects to development in Africa. These themes helped the study to build meaningful units that revealed underlying reasons for African countries' successes and failures in implementing CDM projects. SWOT factors affecting REDD+ implementation were identified and divided into internal and external factors. Internal factors were further subdivided into strengths and weaknesses, while external factors were subdivided into opportunities and threats. This analysis was applied on documents deposited on the UNREDD desk by countries that had partnered with UNREDD and the Forest Carbon Partnership Facility (FCPF). SWOT factors were then prioritized by the frequency of occurrence (score) in the SWOT tables, weighted on a scale of 1–30 and ranked by rights, responsibilities, resources and revenues, commonly referred as 4Rs ranking system as used by O' Hara in (FAO 2012).

RESULTS AND DISCUSSION

Determinants that influenced design and implementation of CDM And REDD+ in Africa

Determinants that influenced design and implementation of CDM projects

Sampled countries that designed and implemented CDM projects had varied determinants that influenced success and failure on different scales. The determinants centered on whether selected countries' experts correctly interpreted governments' declared goals for participating in the CDM, utilized country's sovereign rights to determine best outcomes from cooperation assistance hence, went beyond generic goals agreed in the Kyoto protocol, and utilized underlying goals to build systems and capacity in which CDM projects proliferated (Table 1).

These determinants were quite notable in Kenya, where from the start the country had embarked on a high self-confidence (HSC) approach to build domestic capacity in systems and human resources to understand technical requirements for CDM implementation. This approach separated Kenya from other selected countries that did not strategize to use external support properly hence continued to lean on foreign consultants and developers to formulate and bankroll CDM projects. Kenya used external support to build a formidable national team of experts and systems both in the private, civil society and public sectors that were put to good use to develop and implement CDM projects (UNDP 2006). The country continued to refine and redefine CDM administrative procedures and to re-train Designated National Authority (DNA) members to update them with new methodologies for CDM projects that were approved by CDM Executive Board. This implied that Kenya understood its reasons for participating in CDM beyond the commonly declared goal of accessing development funds from Annex I countries.

Kenya's underlying goal was to build internal capacity, thorough understanding of CDM modalities, guidelines and rules, which knowledge and skills' it applied to facilitate CDM projects. The country pooled domestic expertise with capabilities for successful implementation of CDM projects. Simultaneously, Kenya weaned itself from dependence on foreign consultants, to design, develop and implement ordinary CDM sector projects, hence the country attained medium self-confidence (MSC). This meant that national CDM experts had attained full capabilities to process CDM Projects from Project Idea Note (PIN) to Project Design Document (PDD). Evidently, most of Kenya's CDM projects got approved by the CDM-Executive Board. The processes of attaining (MSC) finally paid off in that Kenya became an investment destination for Annex I countries that needed offsetting carbon. Kenya's internal procedures for CDM projects development became efficient, hence, achieved fast- tracked implementation of CDM projects. Kenya and Uganda were among the most experienced and successful implementers of CDM projects in Sub-Saharan Africa, but financially, Kenya led the pack in the sale of CERs (Cisneros 2012, Hamrick and Goldstein 2016).

TABLE 1 *Determinants that influenced design and implementation of CDM projects in Africa*

Description of determinants	Level of influence/application of determinants in selected countries				
	Zambia	Tanzania	Kenya	Ethiopia	Ghana
Experts correctly interpreted government's declared goals for participating in CDM	++	++	+++++	++	++
Utilization of country's sovereign rights to determine best outcome from cooperation assistance	++	++	+++++	++	+++
CDM programmes beyond generic goals agreed in Kyoto Protocol	+++	++	+++++	+++	++
Utilization of underlying goals to build systems and capacity in which CDM projects are proliferated	++	++	+++++	++	++
Number of operational afforestation and reforestation (AR) CDM projects	0	1	10	1	0
Overall total number of CDM projects	3	4	24	3	3

Key: +++++=Highly notable; ++++ =Notable; +++=somewhat notable; ++= Dismally notable

By contrast, Tanzania's expressed goal for participating in CDM, was to assist Annex I countries offset carbon emissions in exchange for financial and technical support whose purpose was to enhance national technical capacity in designing, formulating and implementing CDM projects. In this regard, the country did not strategize its underlying development goal. Instead of using external support to build internal capacity for development and implementation of CDM projects, the country continued to rely on external financial and technical support to develop and bankroll its CDM projects. This made the country to be overly dependent on external financing and to a large extent this approach made Tanzania to lose focus on building its country's technical, financial, technological capacity in local experts and administrative systems that were required to enhance CDM projects implementation (Pory 2009, Mayungi 2008, NORAD 2012). This low self-concept meant that national experts did not fully grasp the technical dexterity to process CDM projects to reach finesse demanded by the approving bodies. This inadequately qualified local expertise chased project developers away from investing in CDM projects in Tanzania (NORAD 2012). For example, the country's DNA focused on accessing quick finances without considering building national capital and abridged relationships that would enhance overall CDM projects development and implementation. This approach put the country on a path of perpetual reliance on external consultants to support CDM projects implementation. Overall, CDM projects in Tanzania were led by foreign consultants, which ultimately reduced the capacity of local experts to prepare and improve administrative procedures for CDM projects development and implementation. In this regard, Tanzania experienced declined CDM projects activities due to inadequate domestic leadership exacerbated by low carbon credits prices.

The study also revealed that Ghana, Ethiopia and Zambia showed insignificant CDM projects activities due to their low internal capacities to go beyond the commonly accepted goal of waiting for Annex I countries to offset carbon and provide development support. For instance, despite its highly educated and trained scientists, capable of implementing CDM projects, Ghana did not promote CDM projects (Vallejo 2013). It had a low self-concept in CDM projects (Mayring 2000). The technocrats felt incapable of undertaking CDM, which led the country to a general abandonment of implementing these projects.

Ethiopia's case of low participation in CDM projects implementation could be masked by the fact that CDM projects became unattractive after the country had experienced low returns on sale of credits from the Humbo reforestation project. It was also found that Ethiopia had not built strong internal capacity and systems to attract further support to develop its CDM projects (Bekele *et al*. 2015). Ethiopia experienced decline in CDM projects development due to inadequate capacity and low carbon prices. The fundamental reason was that the country had missed the opportunity to use external support to improve its domestic operation environment to enhance CDM projects implementation.

Zambia had implemented only three small-scale CDM projects largely due to inadequate technical capacity and inadequately streamlined procedures for developing and implementing CDM projects (Stilfener 2009). There was inadequate country leadership in Zambia's institutions; starting from the DNA, NGOs and Private sector that could drive CDM projects development (Namugala 2009). The few small scale CDM projects had been formulated by external consultants. Local consultants had peripheral participation since local capacity was inadequate (Stilfener 2009). Low self -confidence (LSC) and low self-concept led the country to evade responsibility to guide CDM projects implementation. Furthermore, discomfiture had characterized early attempts by foreign CDM project developers that had sought government support to develop CDM projects. Zambia's short list of CDM projects demonstrated the country's low self-concept and low self-confidence to undertake CDM projects implementation. Low carbon prices and low conviction to cope successfully with the demands of CDM projects, resulted into the country's overall sub-optimal development of support systems and dismal projects implementation (IDLO 2011).

Determinants that influenced design and implementation of REDD+ projects

Analysis from secondary data showed that from the year 2008, eighteen (18) African countries had implemented REDD+ activities (UN-REDD 2011). Out of one hundred factors identified in five selected countries, SWOT considerations were influential in design and implementation of REDD + projects, fourteen factors with high occurrence were thematically grouped and subsequently discussed (Table 2).

Results of SWOT analysis showed complex interplay of internal and external factors that influenced REDD+ implementation in sampled countries. Presence of forests was the most important strength factor that underpinned the design and implementation of REDD+ projects in selected countries. REDD+ was an important tool for sustainable forest management that also integrated well into AFOLU, Nationally Appropriate Mitigation Actions and Nationally Determined Contributions (Moul 2016). Presence of forests linked well with REDD+ as far as it was a market-based mechanism that promised financial benefits to countries that kept their forests intact (Angelsen *et al*. 2008). The opportunities for REDD+ implementation were availability of stable, free markets for forest based carbon credits that would admit AFOLU sector projects credits. Without functional markets for REDD+ credits, REDD+ projects would cease to function well (FAO 2013).

Whilst there were existing opportunities for design and implementation of REDD+ projects, countries like Ghana and Ethiopia had challenges on institutional frameworks that required to be harmonized (Bekele *et al*. 2015). Tanzania, Kenya and Zambia required refining their subsidiary legislations and institutions to untether REDD+ implementation from a sectorial approach. To enhance REDD+ implementation, 40% of the respondents indicated that increased financial and technical support was needed while 20% considered increased agriculture productivity, adaptation and mitigation to be a way of enhancing REDD+ implementation. Equally, 40% proposed that several options that supported agriculture

TABLE 2 *Factors that influenced design and implementation of REDD+*

Series	Thematic area	Occurrence of theme in SWOT analysis	Priority	Narrations
1	Forests /environment/ ecological as critical components for REDD+ processes	348	1	Presence of forests, suitable environment or ecological habitats with high species abundance and richness, was critical factor REDD+ mitigation and adaptation measures that were capable of increasing ecosystem resilience which is foundation for implementing REDD+ options
2	Financing of REDD+ processes	135	2	This was the most limiting, but very important factor capable of unlocking other factors in the REDD+ design, development and implementation
3	Capacity building	99	3	Critical factor to consider for starting, running and sustaining REDD+ processes
4	Legal/policy/constitutional matters pertinent to REDD+	54	4	This factor was found to be responsible for enhancing or limiting the architecture for REDD+ implementation
5	Technical skills	38	5	Enhances or limits REDD+ design options and subsequent implementation
6	Cross-cutting issues of importance to REDD+	32	6	Gender, poverty and wealth creation were found to be at the core of REDD+ implementation
7	Administrative/power structures as basis for REDD+ implementation arrangements	28	7	Presence of suitable administrative structures and institutional arrangements brought effective and efficiency of REDD+ implementation
8	National/local context in which REDD+ projects are designed and implemented	18	9	State of preparedness to meet with international climate change requirements on gender, carbon ownership, access rights to land among others
9	Weak forest management systems	20	8	This is a precursor for corruption that has potential to contribute to leakage in REDD+ project implementation
10	Stifled fiscal policies	5	12	Reduces potential investment through domestic budget
11	Weak plans/strategies/ programmes	8	11	Policy implementation failure is possible where plans are weak
12	Poverty & gender inequalities	7	13	Inequalities in access to forest resources and ownership can seriously jeopardize REDD+ processes
13	Unidentified capacity needs	17	10	This potentially reduces options for REDD+ as it limits approaches to REDD+ processes
14	Laissez faire in forests management	4	14	Laissez faire is the I don't care attitude that has potential to cripple forest sector administration and render it amenable to self-automation and corruption

farming systems were more important towards addressing the expected impacts of REDD+ projects. In this regard, climate smart agriculture (CSA) fitted well with respondents' suggestion to increase agriculture productivity. This is because, studies have shown that CSA contributed to reduction of deforestation and forest degradation through reducing expansion of farms into forests as a result of increased crop yields/ha. CSA nexus with REDD+ was visible through adaptation and mitigation contributions that came from REDD+ projects implementation (FAO 2012). This made REDD+ to be an important, quick and cheap mitigation mechanism relative to other technologies. However, in promoting several options for agriculture farming systems to enhance REDD+, caution was required as some farming systems like livestock production had the potential to increase GHG emission from ruminal fermentation (FAO 2013). In areas with severe land shortages and little forage, grazing pressure would threaten REDD+ forests. Undoubtedly enhancing REDD+ implementation required cross sector collaboration, which has been emphasized by one expert on REDD+ processes (Angelsen *et al*. 2012).

In this study, respondents were certain that REDD+ sustainability would be ensured through designing REDD+ options that made political sense and also responded to the needs of grassroots communities. There was a need for capacity building among local communities and before financing

implementation of demonstration activities through use of own funds. Usually, external financing addressed high profile training and education while educating the people on REDD+, use of eco-friendly technologies that benefit the local people was left out. To make sense at local levels, REDD+ efforts required to contribute to improvements in people's livelihood through income generating activities and provision of alternative sources of energy. The suggestions in these responses correctly addressed REDD+ sustainability in Africa and would work well with a gamut of approaches for carbon and non-carbon REDD+ options. REDD+ options would be relevant if addressed and implemented with legitimate, equitable, efficient and effective benefit-sharing mechanisms (Lutrell *et al*. 2016).

The future of REDD+ carbon credits trade in the compliance and voluntary markets is critical in overall REDD+ architecture. REDD+ was initially expected to flood the compliance market with cheap credits. If it did, it would push down prices and cause the same problem that was experienced for the CDM credits. However, with its links to Nationally Determined Contributions (NDCs), REDD+ credits, demand is expected to grow and hence push prices upwards (IETA 2014). If prices would be competitive, the future of REDD+ would be assured. If not, it would crumble as did AR-CDM. In the voluntary carbon markets, firm bilateral dedicated buyers (VCS) were the most important customers that were expected to keep buying small quantities of REDD+ credits in order to keep their ecological footprints (Hamrick and Goldstein 2016). Naturally, small dedicated buyers needed to be tagged by producers of carbon as important market that would ensure REDD+ had a good future provided it included carbon and non-carbon benefits, it also worked in synergy with NDCs and Nationally Appropriate Mitigation Actions (NAMAs). African countries needed to formulate options for REDD+ that considered nested and national approaches to get the mechanism on a sustainable basis. The study further revealed that 33.3% of respondents indicated that benefit from sale of carbon credits that were being promoted through carbon benefits sharing mechanism (BSM) was not working for them. But, 66.7% of the respondents acknowledged that they accessed firewood, charcoal, orchids, small wildlife, fruits, vegetables as benefits from forests. They also got agro-inputs such as fertilizers, pesticides as well as seeds to plant and apply in their fields. For example, Kenya's Kasigau Community Ranches REDD+ project interviewees indicated that they were not benefitting through cash transfers from the sale of carbon credits. However, reports by project developers often indicated that cash and non-cash benefits from REDD+ projects were shared with local communities. Quite clearly, there were disparities in opinions expressed by local communities' information on cash benefits sharing provided by REDD+ and CDM project developers. The latter often exaggerated benefits reported giving rise to information asymmetries. This led some authors to sharply criticize both CDM and REDD+ projects implementation as having failed to achieve desired development (UNEP 2013).

Overall, the following determinants formed strengths and opportunities matrix that influenced the design and implementation of REDD+ projects noted in selected African countries:

Treasury support: Financing occupied a very high place in all projects. It was an important strength factor that influenced all the REDD+ projects design and implementation in Africa. Although the major part of REDD+ financing that came from foreign sources was erratic and disproportionate in character, external financial support was comparatively better than the insignificant financing of REDD+ provided under African countries domestic budgets (Nakhooda and Norman 2015, Byrn *et al*. 2012). African countries needed to boost their domestic budget allocations to support REDD+ implementation in order to fill gaps that characterized REDD+ external financing. Although endorsement of the REDD+ mechanism in the UNFCCC was an opportunity for anticipated REDD+ financing (IISD 2015), then pledges from external financing would make sense only if they were premised on home grown programmes and activities as well as domestic budget support, which selected countries' domestic budgets failed to fulfill.

Benefits sharing: This factor motivated stakeholders to participate in REDD+ implementation. Benefits sharing (BS) was a priority strength factor that was central to the success and sustainability of REDD+ in Africa. CDM was unpopular due to its failure to inculcate and deliver sustainable development underpinned by benefits sharing. Equitable distribution of national assets from both carbon and non-carbon benefits was instrumental to poverty eradication among forest dependent communities. REDD+ safeguards included equitable benefits sharing due to its potential to motivate local communities' participation in REDD+ processes (ITTO 2015, Lutrell *et al*. 2016). The centrality of REDD+ benefits sharing to strengthening sustainable forest management (SFM) was that it secured against reversibility of gains made in REDD+ projects implementation (UNEP 2013).

Education, training and research (ETR): These factors related to generation of knowledge and skills, and development of technology for REDD+ implementation. Capacity of nationals to generate, understand and apply scientific models and produce bankable projects was a result of education and training (Dickson *et al*. 2014). The number of professionals, functional science laboratories and education standards in the forestry sector remains low in African countries (FAO 2014). The implication of having atrophied basic education and training as well as research infrastructure was that REDD+ implementation could not be adequately supported on the continent.

Gender: Except in Ethiopia, gender was being well articulated in projects. It was recognized strength factor among selected countries (UNREDD 2009, UNREDD 2012). Tanzania had demonstrated the best gender practices in REDD+ projects. For instance, in Zanzibar women were given a 40- year moratorium to participate in REDD+. In the Malindi REDD+ pilot project, women joined REDD+ in order to continue to harvest non-timber forest products, which gave women a good reason to participate REDD+ project and contributed to maintain forests (Sills *et al*. 2014). These few cases of positive gender participation in REDD+ projects

implementation is important but required to be raised to higher practical levels. In Kenya, for example, there were concerns regarding gender equality in relation to REDD+. It was vividly revealed that Kenya lacked land tenure frameworks that officially recognized women's rights to forest products and carbon from forests (Kiguatha *et al*. 2014). Gender was least articulated and practiced in Ethiopia's REDD+ processes mainly due to centralistic state ownership of all land, which made it difficult for people to own land collectively as communities. Such land ownership regime would hardly support land ownership by gender (EPAE 2011). Gender participation in Zambia's REDD+ projects was difficult to report. Only one REDD+ project was implemented in Zambia (UNEP/DTU 2016). Since, little information on gender was availed from this single REDD+ project, gender in REDD+ projects implementation was untested. Constitutionally, gender was accepted and referenced in all sector laws of Zambia. Although African countries had carried out policy/legal and institutional reforms, gender affirmative actions were not satisfactory on the ground. This left the practical side of gender to rhetoric and emotional inclusions of women men and children into REDD+ projects for the sake of filling up numbers and to flatter cooperating partners for their support.

Weaknesses and threats were also critical determinants that affected the design and implementation of REDD+ projects in Africa. This study considers the following determinants; (i) Laissez faire in forests management, (ii) Stifled fiscal policies, and (iii) Unidentified capacity needs, which are discussed in detail below.

Laissez faire in forests management: One of the veiled weaknesses for REDD+ implementation, was Laissez faire in forest management. This weakness involved human behaviors in which functionaries believed things would sort out without committed efforts. Many forestry managers cared less about ensuring they undertook forest management properly. This negative attitude by was rife and was increasingly affecting health and status of forests. Laissez faire also included political unwillingness to support efforts aimed at sustainable forest management; a condition which was concomitant with lip-service. Hardcastle *et al*. (2010) had identified lip service in Africa's forest management to be responsible for inefficient and ineffective forest management. Lip-service was a disease that permeated international forest policy dialogue, which characterized official rhetoric in Multilateral Environment negotiations and agreements, which ended with the acid test of unfulfilled pledges (UNEP 2007, Reddy 2011, Nakhooda and Norman 2015). Lip-service was also precursor to corruption that weakened forest administration systems (Katoomba 2012). It created negative incentives for REDD+ investors (UNREDD 2008).

Stifled fiscal policies: African governments rarely formulated development policies that parameterized environmental and forest values (Tomppo 2011). This resulted in inadequate knowledge of forest resource composition and full value. REDD+ policies, considered carbon and non-carbon forest values as critical in SFM, but use of fiscal policies that eroded forests for the sake of revenue generation compromised REDD+ forest management principles in many ways, including leakage which ignored these values (AAS 2009, UNREDD 2011). Stifled fiscal policies also led to expenditure of carbon revenues on irrelevant heads (Matakala 2014).

Unidentified capacity needs: REDD+ implementation required that African countries identified specific capacity needs, which they urgently needed to develop in order to implement REDD+. It was necessary that each country undertook capacity needs assessments to identify human resources capacity inadequacies (administrative posts, knowledge and skills gaps) and technological (systems, hard and software, protocols, research and development) after which capacity building support to meet identified shortfalls would be sought. In the current dispensation, African countries lacked even the awareness of the type of support they needed (Dickson *et al*. 2012). Reducing emissions from deforestation and forest degradation was an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions. Thus, capacity for REDD+ implementation was beyond possession of knowledge about REDD+ by a few individuals (UNDP 2006). Capacity for REDD+ implementation should include: (i) engagement of stakeholders, (ii) assessment of a situation and defining a vision and a mandate, (iii) formulation of policies and strategies, (iv) forest management, (v) budget and implementation, and (vi) evaluation of REDD+ programmes and projects (op.cit). Inadequate capacity needs identification was stressed as a weakness partly because African countries failed to reconcile national and nested approaches to REDD+ implementation. The nested approach encouraged REDD+ implementation from lower governance structures towards national REDD+ implementation responsibilities (UNEP 2013). African governments insisted on using a national approach to implement REDD+, hence slowed down the ability of this mechanism to be beneficial to grassroots communities (UNEP 2013). 'Unidentified capacity needs' was an issue in REDD+ implementation because it weakened internal administration.

CONCLUSIONS AND RECOMMENDATIONS

The study concludes that African countries demonstrated various capacities that enabled them to participate in CDM and REDD+ implementation differently. This capacity was built with external support, and further improved by a few countries that used CDM and REDD+ goals as building blocks for developing their underlying national goals. These few countries reached high self-confidence (HSC), which translated their CDM and REDD+ projects implementation into success stories as explained by the quality (breadth and depth) of projects formulated and approved by the CDM-Executive Board and other entities in the case of REDD+ projects. Among the selected countries, Kenya had distinguished itself in this regard while Tanzania and Ghana followed behind in successful implementation of CDM+ projects. REDD+ projects were most advanced in their implementation, in Ghana and Tanzania, while Kenya followed behind. In terms of contributions to national development, CDM

projects failed to usher in anticipated development and were unlikely to achieve this goal in future due to low, sticky prices of carbon credits in the Clean Development Market and also the refusal to admit CERs from the European Union Emissions Trading System (EU- ETS) into the Compliant market by the CDM Board. On the other hand, REDD+ held a promise to address sustainable forest management on condition that people benefited from both carbon and non-carbon products of REDD+ projects. At the moment, it was too early to state that REDD+ had failed or succeeded since it had just entered into implementation of the investment phase, whose results-based payments would definitely determine whether this process would broadly contribute into sustainable forest management and national development for participating member countries.

The study recommend the following actions to policy makers: REDD+ partner countries should undertake more capacity building to improve domestic technical capacity based on capacity self- assessments results. REDD+ implementation should be based on legitimately formulated benefits sharing mechanisms that should be efficiently, effectively and equitably implemented. African countries that performed well in CDM projects and built systems for REDD+ projects implementation should provide and share methodological approaches they had used to attain successful levels in peer reviewed meetings. These lessons would be useful in transitioning to REDD+ projects implementation and investment phases. African countries should also establish their own carbon platforms and operationalize them in order to increase internal demand and ethic for African countries to trade in forest carbon. This study strongly recommends that African carbon marketers should be trained and educated marketers in the operations of Clean Development Mechanism and Voluntary Carbon Markets as well as Over –The –Counter (OTC) emission reduction markets. There was a need to equip African CDM and REDD+ projects managers with knowledge and skills in carbon market analysis and development, which could be gained from education and training, sharing of skills and knowledge through peer-review meetings among other modalities for information sharing.

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Evaluation of forestry-based adaptation practices in flood and drought conditions, and determinants of their adoption in Anglophone Africa

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SUMMARY

This study sought to evaluate forestry-based adaptation practices in flood and drought conditions and their determinants of adoption in the context of strengthening policies, and Agriculture, Forestry and Other Land Uses (AFOLU)-based climate change mitigation interventions relevant to African forestry and its people. The results obtained indicated adaptation interventions were largely planned, autonomous, or a blend of both. The most successful practices in different countries with impact levels above 80% included: agroforestry, particularly in Nigeria, Tanzania and Zimbabwe, alternative livelihoods in Ghana and Zambia, enterprise diversification and extension services for climate-smart agriculture in Zambia, control of forest fires and ecological restoration in Nigeria, use of high yield cultivars in Kenya, irrigation and drought-resistant cultivars in Ghana, and REDD+ in Zimbabwe. The practices were widely adopted based on the following conditions: easy to adapt in cost and technique, community support and participation, directly addressing the needs of people, and a high level of sensitization and awareness. Overall, the most successful and promising adaptation practices identified by stakeholders in country specific context should be up-scaled, promoted and prioritized in the extant policy of agriculture and forestry for greater effectiveness.

Keywords: climate change, adaptation pathways, wider adoption, planned and autonomous adaptation

Évaluation des pratiques d'adaptation basées sur la foresterie en cas d'inondation et de sécheresse, et des déterminants de leur adoption en Afrique anglophone

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Cette étude visait à évaluer les pratiques d'adaptation basées sur la foresterie dans des conditions d'inondation et de sécheresse, à évaluer leurs niveaux de réussite; et les déterminants pour une adoption plus large des interventions les plus réussies dans le contexte du renforcement des politiques d'adaptation pertinentes pour la foresterie et les populations africaines. Les résultats obtenus ont indiqué que les interventions d'adaptation étaient largement planifiées, autonomes ou un mélange harmonieux des deux. Les pratiques les plus réussies dans différents pays avec des niveaux d'impact supérieurs à 80% comprenaient: l'agroforesterie, en particulier au Nigeria, en Tanzanie, au Zimbabwe; les moyens de subsistance alternatifs au Ghana, en Zambie; la diversification des entreprises et services de vulgarisation pour une agriculture climato-intelligente en Zambie; la lutte contre les incendies de forêt et la restauration écologique au Nigéria; l'utilisation de variétés à haut rendement au Kenya; l'irrigation et l'utilisation des variétés résistantes à la sécheresse au Ghana, et la REDD+ au Zimbabwe. Les pratiques les plus largement adoptées étaient basées sur des techniques peu coûteuses et faciles à adapter, un soutien et une participation de la communauté, ou répondaient directement aux besoins de la population et à un niveau élevé de sensibilisation et de prise de conscience. Dans l'ensemble, les pratiques d'adaptation les plus réussies et les plus prometteuses identifiées par les parties prenantes dans le contexte spécifique des pays étudiés devraient être généralisées, promues et hiérarchisées dans la politique agricole et forestière existante pour une plus grande efficacité.

Evaluación de las prácticas de adaptación basadas en la silvicultura en condiciones de inundación, y sequía y determinantes de su adopción en el África anglófona

F.E. BISONG y M. LARWANOU

Este estudio tuvo por objeto evaluar las prácticas de adaptación basadas en la silvicultura en condiciones de inundación y sequía y sus determinantes de adopción en el contexto del fortalecimiento de las políticas y de las intervenciones de mitigación del cambio climático basadas en la agricultura, la silvicultura y otros usos de la tierra que son pertinentes para la silvicultura y la población africana. Los resultados obtenidos indicaron que las intervenciones de adaptación fueron, en gran medida, planificadas, autónomas o una combinación de ambas. Entre las prácticas más exitosas en diferentes países, con niveles de impacto superiores al 80%, están: agroforestería, particularmente en Nigeria, Tanzania y Zimbabwe; medios de vida alternativos en Ghana y Zambia; y control de incendios forestales y restauración ecológica. Las prácticas se adoptaron ampliamente en función de condiciones como la facilidad de adaptación en cuanto a costos y técnicas, el apoyo y la participación de la comunidad, el abordar directamente las necesidades de las personas y un alto nivel de sensibilización y concienciación. En general, las prácticas de adaptación más exitosas y prometedoras identificadas por los interesados en el contexto específico de cada país deberían extenderse, promoverse y priorizarse en las políticas agrícolas y forestales existentes para lograr una mayor eficacia.

INTRODUCTION

Climate change is the current global phenomenon that has stimulated concerns due to its potential threat to human existence. The concerns are more directed to ecologically and economically vulnerable countries, where such risks are expected to multiply the already existing environmental problems (Kojwang and Larwanou 2015, Morrell and Scialabba 2009).

The IPCCs Fourth Assessment Report identify agriculture, forestry and other land uses (AFOLU) as contributing 30% of the total anthropogenic GHG emissions. Agriculture and forestry also have the potential to mitigate between 5.5–6 Gigatonnes of equivalent (e) carbon per year GtCO2e/yr. and 5.4 GtCO2e/yr. Forest ecosystems thus serve the dual roles of fuelling global warming as GHG sources when degraded or converted to other uses through deforestation and becoming sinks for carbon during regrowth or expansion. This puts in context the role of forests in climate change mitigation through the programme Reducing Emissions from Deforestation and forest Degradation (REDD+), sustainable forest management and conservation/enhancement of carbon stocks.

This relationship of forests to global warming and their role in providing services to dependent communities is the convergence point between adaptation and mitigation to climate change in context of AFOLU, and underscores the importance of integrating climate change adaptation and mitigation policies and measures in forest management practices. The role of forests is often overlooked in the context of climate change, but they are vitally important in adaptation. The majority of forest products offer subsistence support for small family-based businesses to aid local community livelihoods, particularly for women. The rate of deforestation coupled with the variability in climate will affect the availability of medicinal plants, fruits, seeds, leaves, roots, and other non-timber forest products (Yaro *et al*. 2016, Bisong and Buckley 2014, Bisong and Atu 2013). Furthermore, trees have long played a pivotal role in traditional agroforestry systems by providing shelter, shade, and protection against the ravages of wind and sun (Bisong *et al*. 2009, Morrell and Scialabba 2009). The intensity of climate will aggravate the problems of resource accessibility and ethnic conflict in shared resources (Brown and Crawford 2008). Besides, forests provide many unseen ecosystem services and functions (Asare and Kwakye 2013).

Africa largely depends on agriculture and forestry for livelihoods and the local economy. In the face of climatic variability, sustainable development is undermined by destroying the natural capital that supports livelihoods and climate. Many countries within the region have therefore been affected by the double impact of flood and drought. In the horn of Africa, 3 million people have been displaced by drought in Kenya, Ethiopia, and Somalia with 13.1 million people affected by food insecurity in communities which have recently endured a long period of drought. Moreover, heavy rains and flooding have also threatened these areas and elsewhere in Africa (Oxfam 2018). In Kenya, flooding has occurred in 40 counties displacing over 332,000 people; in Ethiopia, severe flooding was reported in 14 districts; in Nigeria, at least 14 states have been affected recently by floods among others (PDNA 2012).

Bola *et al.* (2014), in a study of Kanyemba, Mbire District of Zimbabwe, on strategies adopted by households to cope with floods and droughts, found coping mechanisms to be inflexible and poorly suited to adapt to these situations. Similar studies in the rural coastal communities of Nigeria principally among the Ilajes, Itshekiris and Ijaws (Fabiyi and Oloukoi 2013), show these communities utilize indigenous knowledge of local meteorology to predict flooding in real time and on both seasonal and long-term bases, and are thus able to adapt livelihood and social events to the vagaries of climate change. In line with this, the studies by Yaro *et al*. (2016), and Bisong and Andrew-Essien (2010) recommend that indigenous knowledge should be considered alongside other scientific knowledge to combat the impact of climate variability on agriculture to improve crop yield and to promote community conservation of forest resources. They in essence acknowledged the synergies between planned and endogenous adaptation in building adaptive capacity of local people.

Studies dealing with forest-based climate change adaptation have either focused on the endogenous/autonomous policies and measures or the planned interventions which also enhance adaptation and mitigation to climate. Some of these studies (Bola *et al*. 2014, Bishaw *et al*. 2013, Kalame *et al.* 2011 and Paavola 2008) dealt with adaptation interventions targeted at smallholder farmers and highlight the critical roles of exogenous or planned adaptation measures focused on the resilience of agro-ecosystems through agronomic interventions that are socially, economically and ecologically sustainable.

Adaptation and mitigation measures carried out by farmers and other resource users in coping with the climate stress over the years have been ably captured in several policy documents in the continent, including NAMAs, NAPAs, and NDCs of countries to provide the prospect for climate change adaptation and mitigation. Many of these require reinforcement and institutional strengthening for the agencies responsible, particularly in agriculture, forestry, water are resources, energy, and other natural resource sectors.

A critical knowledge gap, however, has been the lack of understanding of the success levels of existing adaptation and mitigation interventions and the synergies between both which translates into many failed policies and measures. These gaps can be better mitigated by identifying and upscaling adaptation and mitigation practices adjudged to be most successful by the stakeholders and promoting their wider adoption and replication by paying due attention to both barriers and success conditions. Considerable amelioration of the deleterious effects of climate change may be attained, particularly in susceptible areas via appropriate adaptation interventions.

Studies delineating the success levels of adaptation actions by endogenous (traditional/local) and exogenous (government/civil society) institutions are hard to find. Furthermore, the patterns of AFOLU based adaptation actions in much of sub-Saharan Africa remain poorly understood. Delineating the pattern of climate change adaptation policies

within the forestry sector is therefore of great interest. Bele *et al.* (2015) in a study of forest-based management adaptation in the countries that constitute the Congo Basin acknowledged the dearth of this contribution stating that forests have received very little attention in policy framework and planning strategies of government. Delineating the contribution of forest management interventions and adaptation to climate change remains a critical gap to be filled in the literature.

The study was, therefore, conducted in seven Anglophone countries in Africa to determine the adaptation practices in flood and drought conditions in the forestry sector, their success levels and the conditions for broader adoption.

METHODS

The study countries

Nigeria, Ghana, Tanzania, Zambia, Kenya, Ethiopia, and Zimbabwe were the Anglophone countries in Sub-Saharan Africa selected as sample sites for the study. The rationale for selecting the countries was the vulnerability of the countries to flood and drought. These countries range from the dry, sub-humid and arid ecological zones in Ethiopia, Tanzania and Kenya, to those with a significant blend of dry and wet conditions in Nigeria, Ghana and Zambia. Zimbabwe represents the southern sub-tropical clime. The selection from the list of the countries affected also accommodated the range of geo-political settings of countries in the continent. Nigeria and Ghana represented Anglophone West-Africa, Kenya and Tanzania representing East Africa, Ethiopia the Horn of Africa, and Zambia and Zimbabwe representing Southern Africa (Figure 1).

Conceptualization of the study

The conceptualization of this study focused on strengthening adaptation policies and AFOLU-based climate change mitigation interventions relevant to African forestry and its people. The conceptual framework developed by Eisenack and Stecker (2012), showed adaptation as consisting of inter-related elements including stimuli, exposure unit, 'operators' (adaptation implementer) and 'receptors' (target beneficiary) and adaptation type. The stimuli are the change in meteorological variables of rainfall and temperature resulting in hazards such as floods and droughts. Exposure units are actors – social, technical, ecological and non-human systems that depend on climate conditions and as a result, exposed to its stimulus. Implementers are institutions including government ministries, departments and agencies (MDAs) and other institutions with means of carrying out the adaptation. Receptors are the beneficiaries/targets, while the typology represents the nature of adaptation intervention (autonomous or planned).

Adaptation has been typified in the literature as anticipatory, reactive, autonomous and planned (IPCC 2007, Sumelius *et al*. 2009). Programmes of public agencies that utilize information about expected future conditions are examples of planned adaptation. Autonomous adaptation is based on endogenous or insider knowledge. Brooks (2003) describes the context under which adaptation occurs as 'endogenous' or 'exogenous'. The former, operating at the local scale, and the later at a broader 'social, economic, political and environmental contexts'. Anticipatory adaptation is action taken ahead of time and therefore different from reactive adaptation intended to affect the present.

The framework drawing from the above-expressed modes of adaptation further characterize adaptation as direct, indirect, facilitating and reflexive. A direct adaptation is said to exist where a receptor is also an exposure unit. The adaptation action is, in this case, focused on improving conditions of a system affected by climate stimulus. Where the receptor and exposure unit are not the same, adaptation can be considered to be indirect. When an operator acts with intent to improve conditions for other actors or biophysical systems, the mode of adaptation is referred to as facilitating. When the operator acts to improve itself, the adaptation is considered reflexive. Inclusive is the adaptation barriers that hinder adoption and enhancement factor that promote adoption.

The framework by Eisenack and Stecker was modified in order to address the objective of this paper (Figure 2). The framework emanates from the understanding that adaptation actions naturally originates as feedback to climate change stresses by one or more actors such as adaptation implementers (operators: households/firms/government, civil society agencies) or beneficiaries as communities/farm families, and so forth.). Ecological, social and technical systems are invariably the units of exposure to stresses from climate change which could undermine the effectiveness of livelihood production systems. The status and success levels of given adaptation are dependent on the balance of influence exerted on barriers or determinants.

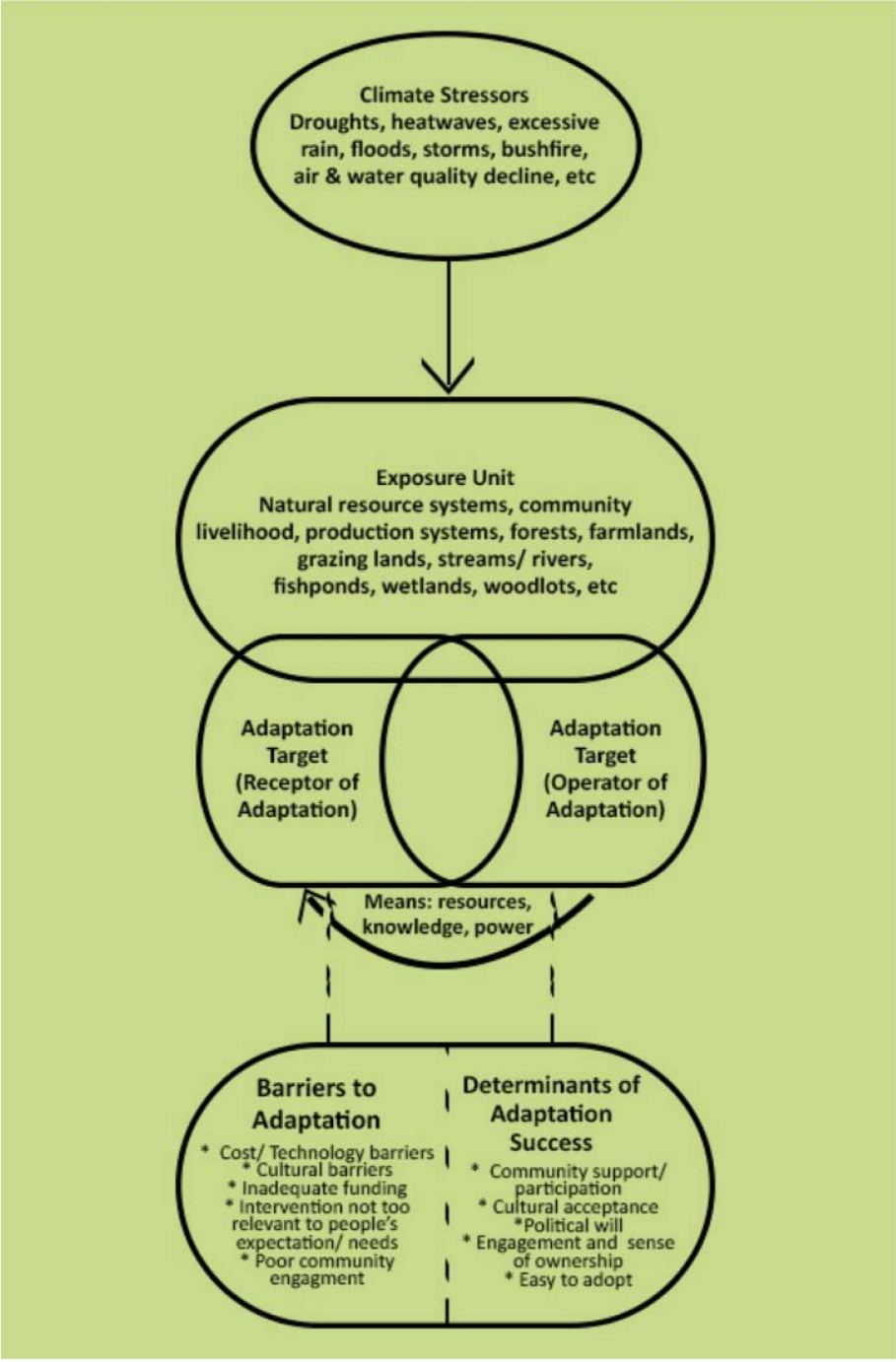
Data collection and procedure

The instrument used for data collection was the questionnaire, designed to obtain data on climate vulnerability patterns, critical adaptation interventions, the success levels of given interventions and the conditions for their wider adoption. The questionnaires were of two sets containing both structured and unstructured questions. The two questionnaires (Instruments 1 and 2) were distributed based on the number of climate change-related agencies and also the number of adaptation project in different countries. A total of 306 AFOLU related MDAs and 77 Projects were identified in the countries selected for the study. Instrument 1 was administered to the heads of the agencies or designated field staff with experience in climate adaptation and mitigation including Non-Governmental Organisations (NGOs) and Civil Society Organisations (CSOs) involved in climate change adaptation and mitigation interventions. The second questionnaire (Instrument 2) was administered to project managers of specific climate change adaptation and mitigation projects intended as case studies of the impacts of such interventions. Three hundred and six (306) copies of instrument 1 were therefore sent to Heads/Focal persons of AFOLU related MDAs, CSOs, and Research Institutions, while seventy-seven

FIGURE 1 *Study Location*

Source: Google Earth 2017

FIGURE 2 *AFOLU based Climate Change adaptation/ mitigation framework*



Source: Author adapted from Eiseneck and Stecker (2012)

(77) copies of instrument 2 were sent to specific adaptation and mitigation projects in the countries sampled. The questionnaire sought information on the type of projects, the adaptation and mitigation measures, implementing agency/ organization (Operators), the beneficiaries (receptors), resources used (means), impacts (exposure unit), the mode of implementation and adoption and the conditions for wider adoption and extent of women's participation. Tables 1 and 2 show the distribution of the questionnaire and return rate by country.

Thereafter, a textual analysis of relevant policy documents namely, nationally determined contributions (NDCs), Nationally Appropriate Mitigation Actions (NAMAs), National Adaptation Programme of Action (NAPAs), National Climate Change Action Plans (NCCAPs), among others were reviewed with a view to delineating, characterizing and evaluating the existing or planned climate change adaptation and mitigation interventions. Both explicit and implicit actions to address AFOLU related climate change challenge were identified and evaluated with due cognizance to cross-country contexts.

TABLE 1 *Distribution on instrument 1*

Countries	No. Sent	No. Returned
Ethiopia	30	0
Ghana	63	10
Kenya	30	4
Nigeria	70	18
Tanzania	15	3
Zambia	49	8
Zimbabwe	49	5
Total	306	48

TABLE 2 *Distribution on instrument 2*

Countries	No. Sent	No. Returned
Ethiopia	14	0
Ghana	12	3
Kenya	10	5
Nigeria	10	3
Tanzania	4	0
Zambia	17	4
Zimbabwe	10	3
Total	77	18

Source: Authors' Field Survey, 2016

The collaborative process of research, debate, and discussion that draws from multiple perspectives across the entire stakeholder spectrum was employed. Experts and professionals in the public sector, i.e. MDAs, Development Partners, CSOs/ NGOs, and the academia within AFOLU sectors in the selected countries were identified and interviewed on AFOLU climate change adaptation and mitigation interventions relevant to their respective sectors and countries. The websites of MDAs, CSOs/NGOs, and research institutes focused on climate change and renewable natural resource management was visited. These included sites of studies carried out by development partners, CSOs/NGOs, and academic institutions on climate change adaptation and mitigation.

A textual analysis of relevant policy documents namely, INDCs, NDCs, NAMAs, NAPAs, NCCAPs, etc. was carried out to delineating, characterizing and evaluating the existing or planned climate change adaptation and mitigation interventions. Both explicit and implicit actions to address AFOLU related climate change challenge were identified and evaluated with due cognizance to cross-country contexts.

Two sets of questionnaires containing both structured and unstructured questions were designed to obtain data on climate vulnerability patterns, critical adaptation interventions, the success levels of given interventions and the conditions for their wider adoption. The success levels of adaptation interventions were assessed on a weighted scale ranging from zero (0) -no impact, to five (5) – high impact, and applied to determine aggregate impact pooled from indicators to determine the extent to which target beneficiaries were reached, extent of adoption and utilization of given interventions, the extent of the participation of women and the extent to which the targeted climate change challenge was resolved. The scores were transformed into percentages to determine their success levels on their aggregated or specific impact areas. Descriptive statistics as means and standard deviations were used to analyze the frequency of responses.

The assigned success levels were:

- < 20 = no impact; 20–< 40 = Very Low;
- 40–< 60 = Low; 60 < 80 = Moderate;
- 80–100 = High.

RESULTS

Forms of forestry adaptation practices in drought condition

The commonest forms of forestry sector adaptation in drought conditions include woodlot establishment, shelter belts against desertification, alternative energy, alternative livelihood, and watershed management (Table 3). The operators are agencies in charge of their implementation, mostly comprising ministries of agriculture, environment, and natural resource management. Receptors are the beneficiaries who differ in scope ranging from farmers and other resource users to the whole communities. Exposure units are the aspects of livelihoods affected, ranging from crops to soils, fuel woods, watershed, etc. The means (resources) employed for adaptation interventions are largely exogenous comprising NGOs, governments and development agency funding. The adaptation practices are largely planned driven by government MDAs, NGOs and development agencies, except in the control of forest fire in Ethiopia and agroforestry in Kenya that are both autonomous (driven by community resources) and planned.

Forms of forestry adaptation practices in flood condition

Adaptation interventions in flood-prone areas of the study region are mostly planned, direct and driven by public agencies in practically all countries investigated (Table 3). These projects range from protecting riparian vegetation and areas enclosure for gully re-vegetation practiced in Ethiopia, watershed and river basin management in Nigeria, Tanzania, Zambia, and Zimbabwe, to wetlands and natural floodplain protection practiced in Ghana and Kenya. The interventions are resourced by governments and NGOs intended to aid communities whose livelihood systems are prone to flood-related hazards. Unfortunately, however, the adaptation interventions in the expressed NAPA and NAMA documents for areas exposed to floods do not take into consideration the role of indigenous knowledge systems and autonomous interventions in dealing with the challenge.

TABLE 3 *Forms of forestry adaptation during drought conditions*

Country	Adaptation practices	Operator	Receptor	Exposure unit	Means	Type
Ethiopia	Enhancing control of forest fire (Awash, Siemen Mountains; Abijata-Shalla, Bale Mountains)	Farmers, Ministry of Agriculture and natural resources, Ministry of Environment and Forest, NGOs	Farmers,	Soil, Farmers' crop, community livelihood	Community resources, extension services	Autonomous, direct and reflexive
	Supporting alternative livelihood (Dire Dawa, Eastern Oromiya, and Somali)	Ethiopia Wildlife Conservation Authority	Community	Community's livelihood, forest resources	NGOs, Government intervention, donor-funded programme	Planned, direct and reactive
	Promoting establishment of woodlot (Tigray)	Ministry of Environment and Forest, NGOs	Community	Community's livelihood, forest resources	Government intervention fund; NGOs, donor fund	Planned, reactive, facilitating
Nigeria	Plantation establishment (woodlots) (Cross River, Benue States)	Ministry of Environment, Department of forestry, academic institutions	Community, Department of forestry	Forest, soil; fuel wood; community livelihood	Donor funds; Government support and NGOs	Planned, reactive, reflexive and facilitating
	Shelter belt against desertification (green wall project) (Borno, Yobe)	Great Green Wall Agency	Community	Community; soil; forest; water resources	Donor funding and regional government support	Planned, reactive; direct; facilitating
Ghana	Plantation establishment (woodlots) (Northern region)	Ministry of Lands and natural resources (Forestry commission)	Community; Forestry commission	Forest; fuel wood; community livelihood	Capacity building, government and NGO's support	Planned, Reactive; Direct and facilitating
	Alternative livelihood (Kumasi, Upper east Region)	NGOs, Community	Community	Community livelihood	Capacity building and incentives from NGOs	Planned, reactive, autonomous
	Alternative energy (Northern region)	Energy Commission; Ministry of Lands and natural resources (Forestry commission)	Community; Forestry commission	Forest; fuel wood; community livelihood	Capacity building, government and NGO's support	Planned, Reactive; Direct and facilitating
Tanzania	Enhancing control of forest fire (Bagamoyo, Rufiji, Mtera, Mbeya, Shinyanga)	MNRT, Private Sector, NGO	Community	Community's livelihood, crops; soil	Capacity building, government and NGO's support	Planned; reactive; direct and facilitating
	Alternative livelihood	Ministry of Energy and Minerals	Community	Community's livelihood, crops;	Capacity building, government and NGO's support	Planned, reactive; direct and facilitating
	Alternative energy	MNRT, Private Sector, NGO, CBO	Community	Community's Energy source	Capacity building, government and NGO's support	Planned, Reactive; Direct and facilitating
Kenya	Watershed management (Kipipiri)	Arid Lands Resource Management Project (ALRMP); Ministry of State for Development of Northern Kenya and other Arid Lands	Community	Forest, water resources	Funding and support by government and NGOs	Planned
	Agroforestry (Eburu forest, Nyakach and Kasipul-Kabondo)	Agricultural Development Corporation	Community	Crop; fuel wood; community livelihood	Community resources, NGOs and government support	Planned

TABLE 3 *Continued*

Country	Adaptation practices	Operator	Receptor	Exposure unit	Means	Type
Zambia	Improvement of fire management systems and soil conservation in Miombo woodlands (plateau and hills) to semi evergreen forests; riparian, swamp and the lake basin, grasslands etc.	Ministry of Environment, Natural Resources and Regional Development Authorities	Community; Ministry of Environment, Natural Resources and Regional Development Authorities	Forest, soil, swamp, grassland	Government funds, NGOs community resources	Planned, reactive
Zimbabwe	Promote catchment protection/ catchment area rehabilitation through agro-forestry (Mashonaland west, Matebeleland)	Ministry of Environment, Water and Climate; Forestry Commission; CSOs	community	Forest and water resources	Funding from Government and NGOs	Planned and reactive
Ethiopia	Protection and enlargement of riparian vegetation; area enclosure to re-vegetate gullies	Ministry of Agriculture and natural resources, Ministry of Environment and Forest,	Community	community livelihood system; forest and water resources	extension services; legal authority, funding by government	Planned and direct
Tanzania	Watershed management; Control habitat destruction and fragmentation along coast forest resources (Zanzibar, Mafia and Kilwa)	Ministry of Natural Resources and Tourism (MNRT); Private Sector, CSOs	Community	Community livelihood, and water resources	capacity building by NGOs and funding from government	Planned and Direct
Nigeria	River basin management; watershed management, SLM (Niger Basin, Benue)	Ministry of Environment; Forestry commission, Basin development authority; NGOs	Community	Community cropland; fuel wood and livelihood	capacity building by NGOs and funding from government	Planned and Direct
Ghana	Natural floodplain protection, (Accra)	Forestry commission; environmental protection Agency	Community	Community livelihood and water resources	capacity building by NGOs and funding from government	Planned and Direct
Kenya	Protection of wetland and SLM (Northern Kenya)	National Environment Management Authority (NEMA); Ministry of State for Development of Northern Kenya and Other Arid Lands (MSDNKOAL)	Community	Community livelihood	capacity building by NGOs and funding from government	Planned and Direct
Zambia	Catchment-wide management and livelihoods (Copperbelt, Lusaka)	Ministry of Environment, Natural Resources and Regional Development Authorities; Forestry department	Community	Community livelihood system	Government funding; capacity building by NGOs	Planned and Direct
Zimbabwe	Implement catchment protection measures; land-use plans (Mashonaland)	Ministry of Environment, Water and Climate; Forestry Commission; CSOs	Community	Community livelihood system	Government funding; capacity building by NGOs	Planned and Direct

Promising practices on forest-based adaptation measures

The success levels of adaptation interventions were assessed on a weighted scale ranging from zero (0) – no impact, to five (5) – high impact. The most successful adaptation interventions were determined by a pooled or aggregated rating of each intervention on the basis of their effects on livelihood improvement, extent to which target beneficiaries were reached, extent of the adoption and utilization of the interventions, extent of the participation of women and the extent to which the targeted climate change challenge was resolved. At aggregate levels of generalization on a continent-wide basis, eleven climate change adaptation interventions were deemed highly successful attaining the score of 80% and above on the weighted scale (Figure 3).

These were:

i. Agroforestry – Nigeria (80%), Tanzania (83%), Zimbabwe (85%)
ii. Alternative livelihood – Ghana (80%), Zambia (92%)
iii. Control of forest fire – Nigeria (86%)
iv. Ecological restoration – Nigeria (80%)
v. Enterprise diversification – Zambia (90%)
vi. Extension services for climate smart agriculture – Zambia (86%)
vii. Irrigation – Ghana (83%)
viii. Plantation establishment – Ghana (86%)
ix. REDD+ - Zimbabwe (80%)
x. Use of high yielding cultivars/breeds – Kenya (80%)

Conditions for wider adoption of adaptation practices

The conditions for adoption of adaptation interventions were also assessed on a weighted scale ranging from zero (0) - no impact, to five (5) – high impact. The most significant reasons advanced for the wider adoption of the more successful adaptation interventions are shown in Figure 4.

The greater proportion of respondents identified the ease with which a given adaptation intervention can be adopted in terms of cost and technical application, as the most common condition for adopting adaptation practices. This is followed by community support and participation, adaptation that more directly addresses the needs of people, and those with more obvious results. Others include high levels of sensitization and awareness, proper implementation strategies, cultural acceptance, engagement and a sense of project ownership and political will.

Effects of adaptation on livelihoods

Participation of women is the one of the criteria used in assessing successful levels of adaptation interventions across the different countries. Women are extensively involved in farming and forestry related activities, their participation and adoption of the adaptation practices determines wider adoption that can easily spread. Figures 5 highlights the extent of women participation in adaptation interventions at aggregate and country specific levels.

At aggregate scenarios, women are evidently most successfully participating in a range of adaptation intervention activities such as plantation establishment (100%), extension service for climate smart agriculture (100%), shelter belt establishment (86%), alternative livelihood/enterprise diversificationprogrammes (86%), apiculture (80%), and aquaculture (80%), among others. In these, they attained a success rating of ≥ 80% in terms of their participation. The same may be observed in country specific contexts albeit, with differences based on peculiarities of given countries.

Indigenous knowledge adaptation

Indigenous knowledge systems provide pathways for climate change mitigation and adaptation across Africa. Numerous practices including traditional conservation agriculture, agroforestry systems and farm forestry are common coping strategies to ameliorate the impact of climate change. Figure 6 highlights indigenous adaptation and mitigation strategies adopted in the continent. The most common being the intercropping and mixed cropping systems (18%). Others include rainwater harvesting (8%) and the utilization of high yielding short rotation species (8%).

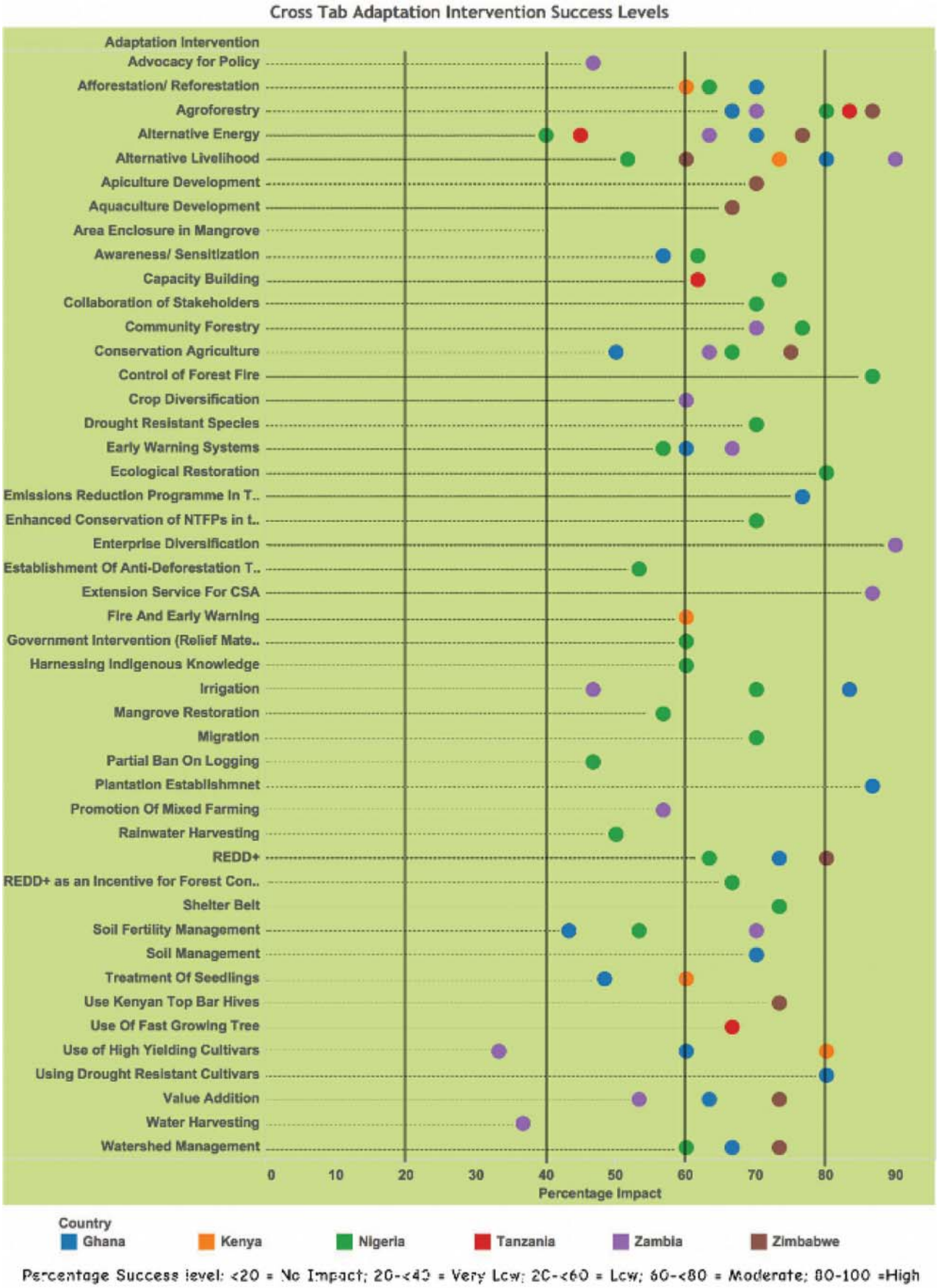
DISCUSSION

Data from recent literature on the historical perspective of climate change shows that the continent of Africa is already under threat from climate change. Evidence from scientific data confirm that the continent is becoming warmer and drier, while rainfall is becoming less predictable (Chichongue *et al*. 2015). Several adaptation practices have been adopted by farmers and other resource users to cope with climate change comprising water resource management, irrigation techniques, drought tolerant cultivars/breeds, conservation agriculture, and early warning systems, agroforestry systems, etc. These interventions are largely planned, i.e. driven or implemented by public institutions (government agencies, NGOs, or development partners), or a blend of autonomous (driven by individual, household or community resources and skills that rely on indigenous and local knowledge) and planned adaptation. This is in line with the assertion by IPCC (2007) and Sumelius *et al.* (2009) that adaptation in the context of climate change can be typified as anticipatory, reactive, autonomous and planned.

The most successful practices in different countries include, agroforestry, alternative livelihood, control of forest fire, ecological restoration among others. Agroforestry for instance showed high success levels of between 80–100% particularly in Nigeria, Tanzania and Zimbabwe. This is in accordance with the findings by Verchot *et al.* (2007) and Hailesilassie (2015) that agroforestry plays a critical role in mitigating climate change in tropical subsistence agriculture, thus, helping smallholder farmers adapt to climate change (Leal-Filho, *et al.* 2017).

These practices can be made effective and widely adopted under certain conditions which include: making them easier

FIGURE 3 *Adaptation interventions success level*



Source: Authors' Field Survey, 2016

FIGURE 4 *Determinants for wider adoption of adaptation measures*

to adopt in cost and technique, fostering community support and participation, ensuring they directly address the needs of people, high level of sensitization and awareness, ensuring proper implementation strategies, cultural acceptance, engagement and sense of project ownership and political will. Mbow *et al.* (2012) also affirmed that addressing equity and gender issues in the adoption of climate change adaptation and mitigation practices is one of the major challenges that requires extra efforts. Enete and Achike (2008) and Cavane (2011) indicated the failure of some interventions due to some challenges and opted for practices that will be easier to adopt. Smith *et al.* (2014) also opined that if funding is designed in such a way that access is easy and transparent, it will help to modify and enhance economic activity, as well as potentially providing ample opportunity to leverage a larger proportion of intervention potentials.

Given the high level of success in the participation of women in a range of adaptation intervention activities in the continent, they should therefore become extremely important as stakeholders to be targeted in programmes meant to facilitate and upscale the adoption of successful adaptation intervention practices.

FIGURE 5 *Extent of women participation in adaptation to climate change*

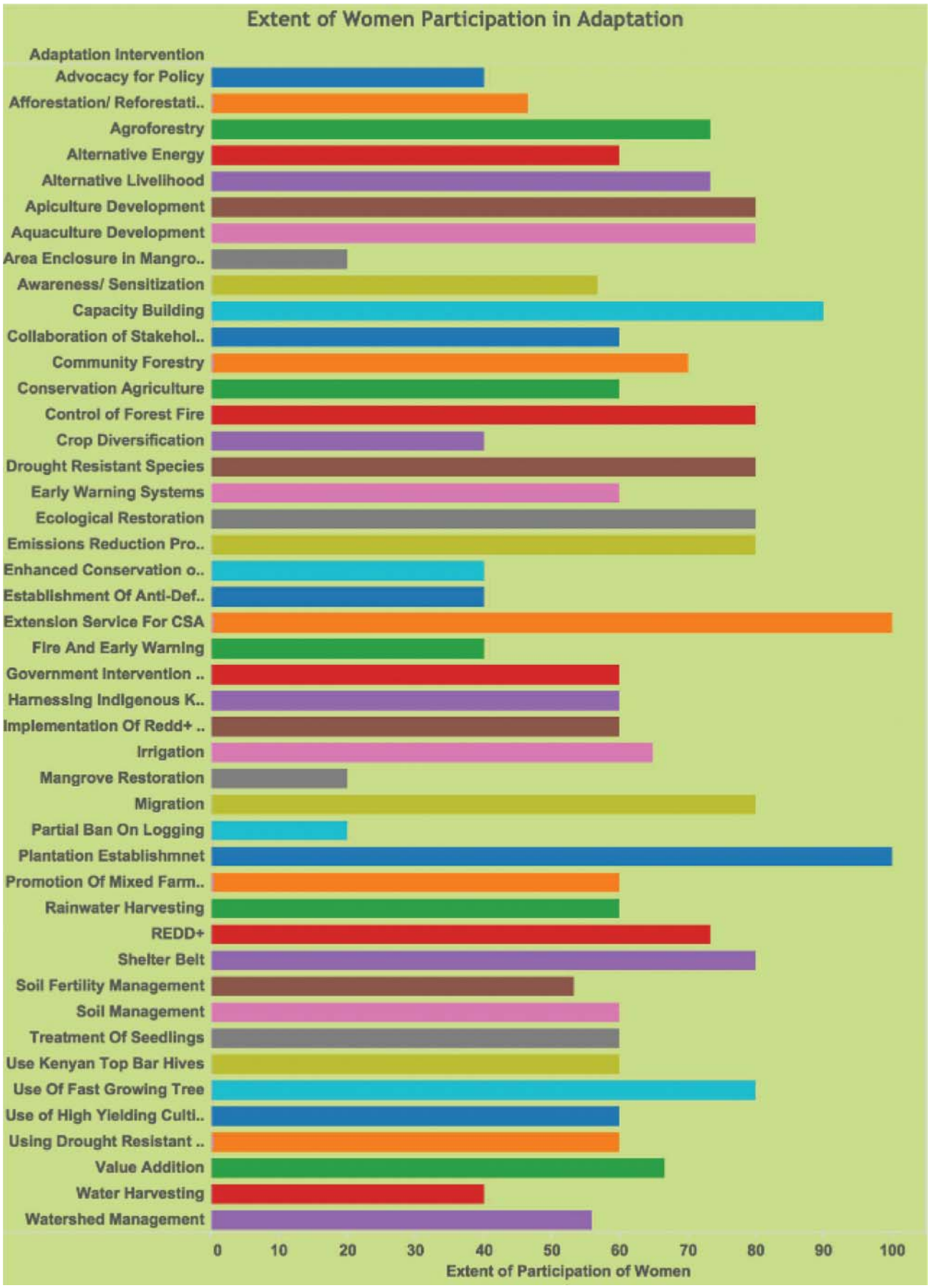
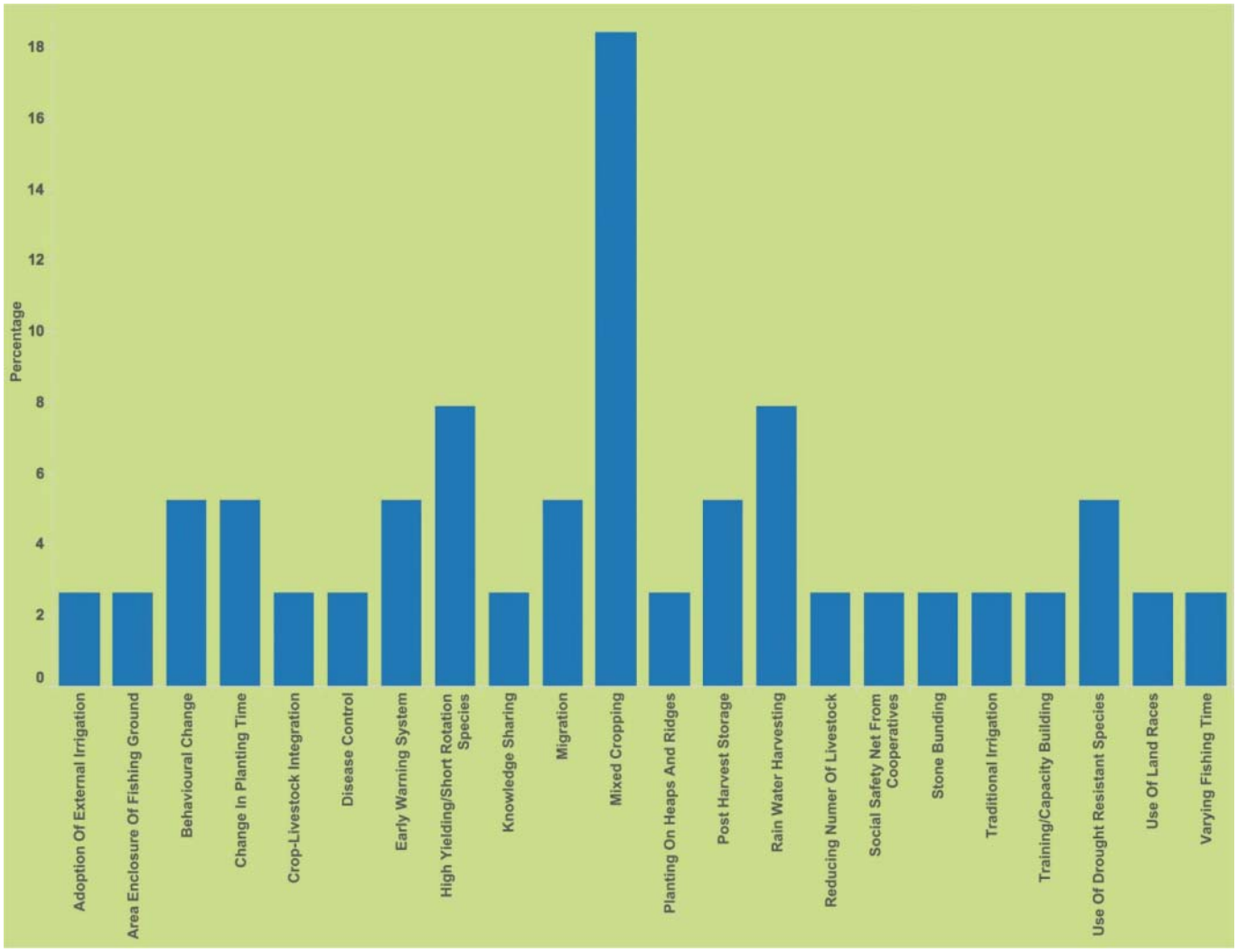


FIGURE 6 *Indigenous people adaptation mechanisms*



Source: Authors Field Survey, 2016

The absence of autonomous/endogenous adaptation as a flood control and flood prediction mechanism in the forestry sector in the NAPA is evidenced by documents of all countries investigated indicating that little recognition is placed on indigenous knowledge systems by policy makers and practitioners in the continent. This is despite the abundant evidence of the value of these systems in providing effective coping mechanisms to flood related problems for many communities in the coastlines and wetter regions of the continent.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Adaptation intervention measures which are presently on-going in the continent are largely planned, autonomous, or a combination of both. Given the potential value but limited resource capacity of indigenous adaptation practices, there is need for collaboration and synergies with planned adaptation interventions of public agencies for maximum impact.

Agroforestry, enterprise diversification, ecological restoration, alternative livelihood, plantation establishment, use of high yielding species etc. are the climate change adaptation interventions deemed highly successful in Africa. Certain conditions favorable for their wider adoption have been captured, the core of which are affordability, technically applicability and significant community buy-in based on relevance, social and cultural acceptance, and enhanced level of awareness and sensitization among others. Women are evidently most successfully participating in a range of adaptation intervention activities such as plantation establishment, extension services for climate smart agriculture, shelterbelt establishment, alternative livelihood/enterprise diversification programmes, and apiculture, etc.

Numerous adaptation measures/interventions have been adopted by farmers and other resource users in different countries. Agroforestry, alternative livelihood, control of bushfires, and ecological restoration among others are other adaptation practices across Africa with high potential.

Recommendations

- Promising adaptation interventions should be integrated into the plans and policies of the relevant MDAs such as Ministry of Agriculture, Environment and Natural Resources. Up-scaling these promising adaptation interventions is critical to stimulate extensive adoption for improved productivity.
- Adaptation policies to climate change in the AFOLU sectors should be structured to enhance the conditions/ determinants for wider adoption of adaptation measures and incorporate them into the major activities and plans of relevant agencies. Practices geared towards sustainable land and forest management are the prominent adaptation action in Africa. However, these practices require a harmonious conditions for their wider adoption. Harmonization of land and forest utilization and conservation among the various agencies and organization needs to be carried out to deliver sustainable development on a common ground.
- Women should be made valued and strategic stakeholders in programmes designed to up-scale and replicate successful adaptation interventions.
- Indigenous knowledge should be integrated with scientific knowledge in order to boost the knowledge stream for sustainable development
- A system must be in place for easy dissemination and access to information on climate change and adaptation. Moreover, building adaptive capacity requires a strong collaboration between MDAs, civil society groups and local community actors, and the political will of both national and sub-national government as well as an understanding of the depth of the impact to proffer solutions to the problems. Eliciting community involvement and commitment through a robust participation framework is also essential.

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Pathways for harmonizing forest-related climate change adaptation and mitigation in Francophone Africa

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SUMMARY

The role of forests in climate change mitigation is well documented. However, little is known about the importance of forests to adaptation in response to climate change, and its integration with mitigation options to cushion social and biophysical systems from the impacts of climate change. This paper examines pathways for harmonizing forest-related climate change adaptation and mitigation in francophone Africa covering Burkina Faso, Côte d'Ivoire, Democratic Republic of Congo, Madagascar and Cameroon. Qualitative and quantitative research approaches were employed in this study. It was found that wood energy savings, afforestation, reforestation, promotion of community forests, agro-silvi-pastoral schemes and urban forestry schemes were the most identified interventions with a potential of climate change adaptation and mitigation outcomes. In this regard, mainstreaming forests into adaptation and mitigation policies in the context of NDCs is critical if the benefits from forests and trees outside forests are to be realized in Francophone Africa.

Keywords: forests, climate change, Nationally Determined Contributions (NDCs), adaptation, mitigation

Chemins d'harmonisation de l'adaptation du changement climatique dans le domaine forestier avec une atténuation du problème en Afrique francophone

M. NGANJE et M. LARWANOU

Le rôle des forêts dans l'atténuation du changement climatique est bien documenté. Cependant, l'importance des forêts dans l'adaptation en réponse à ce changement climatique est peu connue, ainsi que l'intégration de cette adaptation dans des options d'atténuation visant à protéger les systèmes biophysiques et sociaux des impacts dudit changement. Cet article examine les chemins à emprunter pour harmoniser l'adaptation et l'atténuation du changement climatique dans le domaine forestier en Afrique francophone, recouvrant le Burkina Faso, la Côte d'Ivoire, la République Démocratique du Congo, le Cameroun et Madagascar. Des approches de recherche qualitatives et quantitatives ont été employées dans cette étude. On trouva que l'économie de l'énergie provenant du bois, la reforestation, le boisement, la promotion des forêts communautaires, les schémas agro-sylvi-pastoraux et de foresterie urbaine étaient les interventions les plus identifiées comme ayant un potentiel de produire des résultats d'adaptation au changement climatique et à son atténuation. A cet égard, l'intégration des forêts dans des politiques d'adaptation et d'atténuation dans le contexte des NDCs est critique, si les bénéfices des forêts et des arbres hors-forêt veulent pouvoir être réalisés en Afrique francophone.

Vías para armonizar la adaptación y la mitigación al cambio climático relacionadas con los bosques en el África francófona

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El papel de los bosques en la mitigación del cambio climático está bien documentado. Sin embargo, se sabe poco sobre la importancia de los bosques para la adaptación en respuesta al cambio climático y su integración con las opciones de mitigación para amortiguar los sistemas sociales y biofísicos de los impactos del cambio climático. Este documento examina las vías para armonizar la adaptación y la mitigación al cambio climático relacionadas con los bosques en los siguientes países del África francófona: Burkina Faso, Costa de Marfil, Madagascar, Camerún y la República Democrática del Congo. En este estudio se emplearon métodos de investigación cualitativos y cuantitativos. Se encontró que el ahorro de dendroenergía, la forestación, la reforestación, la promoción de los bosques comunitarios, los sistemas agrosilvopastoriles y los sistemas de silvicultura urbana fueron las intervenciones identificadas más a menudo con un potencial de lograr resultados para la adaptación y mitigación al cambio climático. A este respecto, la incorporación de los bosques en las políticas de adaptación y mitigación dentro del contexto de las contribuciones determinadas a nivel nacional (CDN) es fundamental para que los beneficios de los bosques y los árboles fuera de los bosques se hagan realidad en el África francófona.

INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) has estimated that more than one-third of the world's remaining forests may be negatively affected by climate change over the next century. This will diminish the quantity and quality of goods and services that forests and forest ecosystems deliver to society (FAO 2011). Developing countries and their societies will be affected most, due to their intimate dependence on forests and forest ecosystems for economic benefits and livelihood (FAO 2014). The urgency for adaptation to climate change was expressed by IPCC's 4th Assessment Report (IPCC 2007, Sonwa *et al*. 2012). The UN Framework Convention on Climate Change (UNFCCC) mandated highly vulnerable Least Developed Countries with low capacity to respond to climate change, to prepare national adaptation programs of action (NAPAs) that highlight their priorities based on evaluations of their national contexts (Sonwa *et al*. 2010). IPCC (2007) defines adaptation to climate change as the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderate harm or exploit beneficial opportunities (Ravindranath 2007). Ecosystem-based Adaptation (EbA) meanwhile, described as 'the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change' was adopted at the Convention on Biological Diversity (CBD)'s COP 10 in Nagoya, Japan in 2010 (Andrade *et al*. 2011:7). As an ecosystem, forests benefit from this inscription and since the 11th climate change COP in Marrakesh, have progressively materialized as being strategic in international efforts to address climate change (Locatelli *et al*. 2008).

In addition to adaptation to climate change, the UNFCCC's objective of limiting global warming involves support for the development of carbon sinks including through forest-based climate change mitigation actions (FAO 2010). Mitigation of climate change is defined as any human undertaking likely to enhance carbon sinks and capable of reducing the sources of greenhouse gases (IPCC 2007, Swart and Raes 2007). The climate change mitigation role of forests has been boosted in international climate change discourses by the 'Nationally Appropriate Mitigation Actions' or NAMA process, adopted as a scheme for supporting pre-2020 climate change efforts during the Cancún Agreements of 2010 (Morel *et al*. 2012). Signing countries agreed, "*that developing country Parties will take nationally appropriate mitigation actions in the context of sustainable development, supported and enabled by technology, financing and capacity-building, aimed at achieving a deviation in emissions relative to 'business as usual' emissions in 2020*" (Cancún Agreements 2010, Morel *et al*. 2012:14). The term 'nationally appropriate' in the Cancùn Agreements, gave developing countries flexibility in selecting projects for support. There was apparently little or no restriction on size, sector or partnerships in so far as mitigation was targeted (Morel *et al*. 2012), which easily led the climate change COP20 in Lima to propose the more comprehensive post-2020 INDCs process (currently NDCs). Parties to the UNFCCC decided "*to invite all Parties to initiate or intensify domestic preparations for their 'Intended Nationally Determined Contributions'... and to communicate them well in advance.... in a manner that facilitates the clarity, transparency and understanding of the intended contributions*." (COP Warsaw 2013, Boos *et al*. 2015:7). Consequently, in addition to mitigation, NDCs can also comprise elements that address adaptation, finance, technology and capacity building (Boos *et al*. 2015).

Meanwhile, climate change adaptation and mitigation both contribute towards the UNFCCC's main goal of buffering the adverse effects of climate change (Chia *et al*. 2014). In most cases, adaptation and mitigation strategies have been detached and treated as separate topics under the UNFCCC (Chia *et al*. 2016). This is understandable at the level of the science where their methodological approaches are different. They have also been portrayed as enshrining differences in time and space, with mitigation targeting the alleviation of medium to long-term climate impacts and driven by global and national interests and stakeholders, while adaptation is depicted as targeting short-term impacts of climate change, driven by local interests, such as coping strategies at community level (Somorin *et al*. 2011). Notwithstanding these differences, the famous Bali Roadmap of the UNFCCC specifies that, actions that seek to safeguard food security and rural livelihoods under climate change in the coming decades must focus on the synergy between adaptation and mitigation strategies in both the agriculture and forestry sectors. This is of utmost relevance if such actions are also to address environmental, social and economic concerns expressed within both the UNFCCC and the Millennium Development Goals (Tubiello 2011). Nowhere is this more relevant than in Sub-Saharan Africa, where specialized climate-related expertise in quality and quantity is limited and facilities inadequately equipped. In addition, due to exacerbating poverty, politicians tend to prioritize investments targeting the social sectors as a result of their faster returns, sometimes to the detriment of environmental resources.

The duplication of effort between adaptation and mitigation initiatives in Sub-Saharan Africa including francophone Sub-Saharan Africa has been recognized by previous studies. For example, (Somorin *et al.* 2011), whose study examined the policy discourses on climate change adaptation and mitigation in the forest sector of the Congo Basin, covering; Cameroon, Central African Republic and the Democratic Republic of Congo, distinguished advocates for a mitigation-only approach, others for a separate mitigation-adaptation format and those for an integrated adaptation-mitigation framework. In their description of the mitigation-only approach, sturdily promoted by the private forest sector, they indicated that a justification usually advanced in favor of this approach is that human systems have historically coped and adapted to environmental changes as a way of life (Somorin *et al*. 2011). This implies that there was nothing new as far as adaptation to climate change was concerned. Pertaining to the separate adaptation and mitigation policy discourse, among other reasons, adaptation advocates insist that adaptation policies are best for the poor, whose livelihood is intimately linked to the forest. According to these advocates, the simple way of life of 60 million forest dependent people of the Congo Basin will be compromised under the highly scientific

processes advocated by mitigation processes such as REDD+ (Somorin *et al*. 2011, Tiani *et al.* 2014). From recent studies in countries of Central Africa's Congo Basin, some interviewed stakeholders consider adaptation and mitigation as synonymous (Tiani *et al*. 2014). Further justification for integrating these two approaches appear far-reaching in cases where afforestation and reforestation projects are submitted for adaptation finance and the same projects submitted for mitigation funding (Chia *et al*. 2014).

Several approaches have been proposed to harmonize climate change adaptation and mitigation. For example, by harmonizing policies, laws and strategies (Somorin *et al*. 2011, Duguma *et al*. 2014, Ngum *et al*. 2018); by working through the different actors involved (Chia *et al*. 2014); by using networks (Ngum *et al*. 2018) as well as by creating coalitions (Somorin *et al*. 2011). Others include proposals to create a 'National Technical Committee' to oversee and provide scientific guidance on the synergies between climate change adaptation and mitigation (Ngum *et al*. 2018); improve cross-sector structures to coordinate concerted efforts (Kojwang and Larwanou 2015); use participatory approaches in order to benefit from appropriate scientific knowledge while retaining a focus on values important to stakeholders (Tubiello 2012), and a comprehensive approach in project design (Chia *et al*. 2016). Implemented projects currently integrating adaptation and mitigation approaches have also been recorded such as Senegal's national effort that is increasing tree cover by fencing groundnut farms with hedgerow plantings (Kojwang and Larwanou 2015), and in Benin where the conservation and sustainable use of gallery forests, overseen by local forest management institutions is reducing the risk of flooding, conserving and enhancing forest cover, promoting non-timber forest products and medicinal plants, and ecotourism (Paul *et al*. 2013).

The current study on pathways for harmonizing forest-related climate change adaptation and mitigation in francophone African countries is anchored on the research proposing to engage comprehensive project design (Chia *et al*. 2016). It posits that as much as possible, projects that seek to demonstrate synergy between climate change adaptation and mitigation should be identifiable from the project title as a strategy to provide up-front guidance to project design. It demonstrates this strategy by engaging stakeholders to examine and prioritize 26 forest and climate change project ideas collated from NDC documents enriched with others from country NAMAs of 5 francophone African countries for their fit with climate change adaptation and mitigation. Based on 10 prioritized project ideas selected by respondents, the research demonstrates how to develop project titles into pathways likely to enshrine both adaptation and mitigation outcomes.

METHODOLOGY

The study on 'pathways for harmonizing forest-related climate change adaptation and mitigation in francophone Africa' was commissioned by the African Forest Forum (AFF). It was undertaken as part of a wider study, titled: 'Strengthening adaptation policies and AFOLU based climate change mitigation interventions relevant to African forestry and people'. The study involved visits to five francophone countries, namely: Burkina Faso, Côte d'Ivoire, Democratic Republic of Congo (DRC), Madagascar and Cameroon. The countries were selected based on their forest vegetation types and geographical location. The West African sub-region; characterized by dry forests in parklands of the Savannah/Sahel and Guinean Moist Forests, was represented by Burkina Faso and Côte d'Ivoire respectively. The Central African sub-region; characterized by evergreen moist forests of the Congo Basin, was represented by Cameroon and the DRC, while the South and East African sub-regions; characterized by spectacular deciduous forests and woodlands, were represented by Madagascar (Figure 1).

The study took place between March and May of 2016 preceded by official letters of information and introduction of the researcher issued by the African Forest Forum Secretariat to Directors of national and regional projects and programs on forests and climate change in the five study countries. Institutions targeted for the study included 4 government agencies per country that were most knowledgeable of NDC planning i.e. forestry, environment/climate change, agriculture and water/hydraulics. Additionally, the researcher organized to interview representatives of intergovernmental organizations, research agencies, international organizations, divisional administrative authorities (prefects), municipal authorities (mayors), the private sector, civil society and community organizations based on their likelihood to be involved in NDC planning and /or execution and their accessibility.

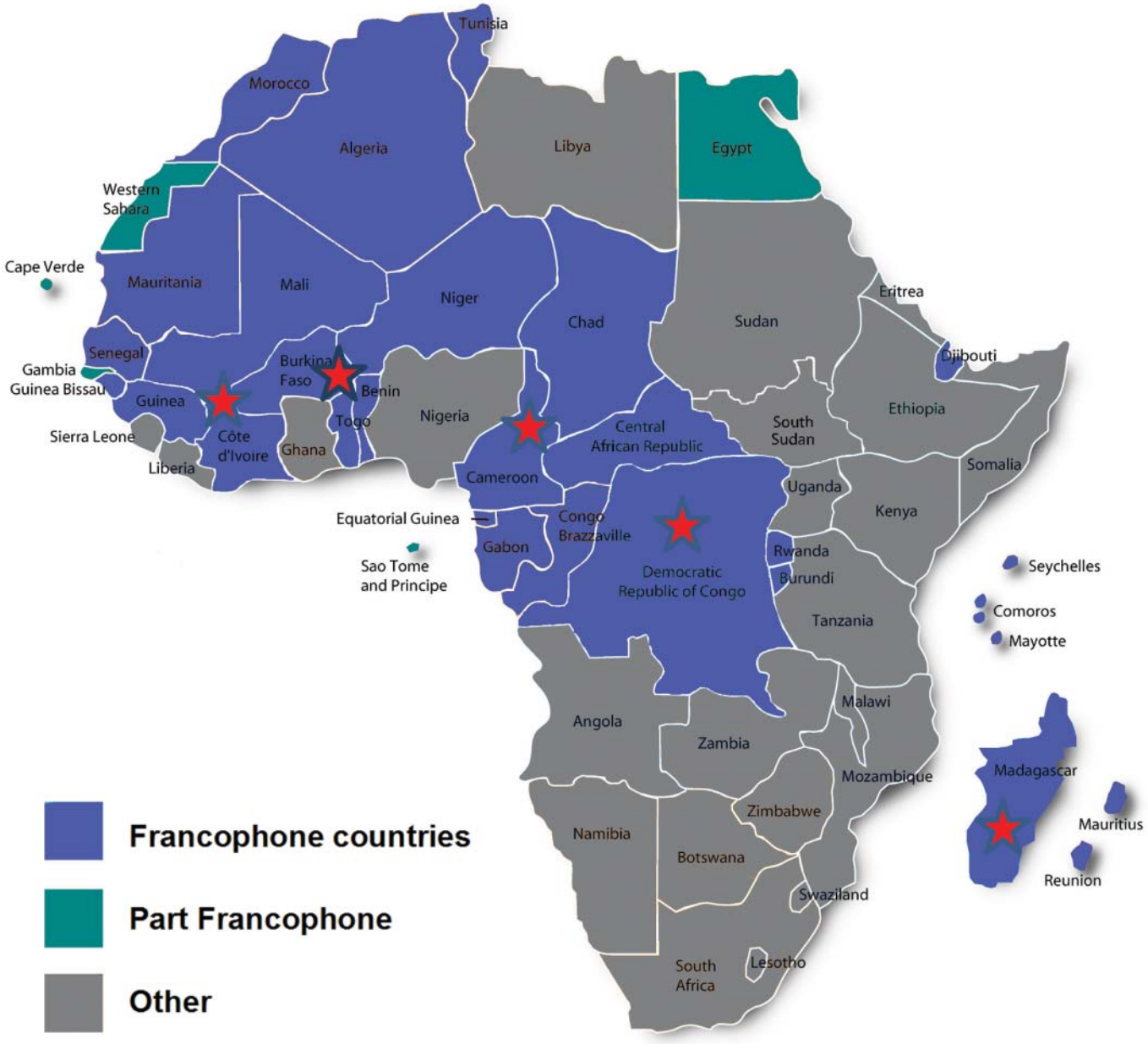
The full study involved 8 research areas, namely: (1) evaluation of prospects for wide adoption of promising practices on adaptation measures; (2) analyses, documentation and sharing of relevant forest-related mitigation approaches in AFOLU as applied in the African context; (3) assessment, documentation and sharing information on the impact of applicable AFOLU mitigation activities on food, fuel and fibre production; (4) assessment of applied policies in forest NAMAs and identification of best practices; (5) identification and evaluation of policies and activities in African countries that incorporate both adaptation and mitigation characteristics; (6) assessment of carbon policies and practices at national and sub-regional levels supporting /constraining development of initiatives on carbon; (7) assessment of key African institutions that have the potential to effectively address governance of climate change in forestry; and (8) assessment of potential high-impact pathways and mechanisms to address governance of climate change in forestry.

This paper concerns research area 5 i.e. 'identification and evaluation of policies and activities in African countries that incorporate both, adaptation and mitigation characteristics'.

Three non-quantitative research methods were employed to collect information for the study, namely:

(a) Consultation of secondary data. This included national documents of the study countries related to forests and climate change adaptation and mitigation, especially NDCs, supplemented with NAMA project ideas likely to be useful beyond 2020, constituting the end of the NAMA scheme;

PLATE 1 *Francophone countries of Sub-Saharan Africa with star visited during the study*



NB: From left to right: Côte d'Ivoire, Burkina Faso, Cameroon, DRC and Madagascar.
Source: http://ktnetafrica.net/sites/default/files/Newsletter%20Issue%201%202015-Final%20.pdf

(b) Visit to selected countries for interviews and discussions with stakeholders guided by descriptive, structured and open-ended questions. Because of the short duration of country visits (not more than 3 working days), discussions provided the opportunity to share contact addresses for follow-up exchanges with respondents who could not be interviewed during such visits; and
(c) Exchanges on Skype, email and telephone with respondents after the country visits for follow-up clarifications and submission of their contributions to the researcher.

Data collection involved collating project ideas from NDC documents enriched with others from NAMA plans likely to be taken up beyond 2020 at the end of the NAMA scheme. More specifically, a list of 26 project ideas were collated from the NDCs' of Burkina Faso (Burkina Faso 2015), Côte d'Ivoire (République de Côte d'Ivoire 2015), Democratic Republic of Congo (République Démocratique du Congo 2015), Madagascar (République de Madagascar 2015), and Cameroon (République du Cameroun 2015) as well as from national NAMA reports in UNFCCC documents (UNFCCC 2015). The collated project ideas were shared with respondents and discussed during face-to-face interview sessions.

TABLE 1 *Profile and constituencies of respondents of the study*

Affiliation	Number of respondents	Professional constituency of respondents
Government [12 Agencies]	22	Government Ministries: Forestry (10), Environment/Climate Change (10), Agriculture (1), Water/Hydraulics (1).
Intergovernmental organizations [3]	4	COMIFAC (1), MRU (1), Africa Great Green Wall Initiative – Burkina Faso (2).
Research agencies and related organizations [3]	6	CIFOR (2), IITA (1), CSRS (3).
International organizations [4]	8	FAO (2), IUCN (2), WWF (3), WCS (1).
Prefects, Mayors, Civil society, and community organizations [5 institutional units]	8	Ngoyla-Mintom REDD+ Cameroon (2), FMTE/Nouamou community Côte d'Ivoire (2), Boni Biofuel community Burkina Faso (2), Boni Mayor /Prefect Burkina Faso (1), Boni Community Forestry Post Burkina Faso (1).
Private sector [4]	5	AGRITECH – Biofuels Burkina Faso (2), SFID-Djoum Cameroon (1), Afrique-Comfort Vannerie – Cameroun (1), APFNP-Côte d'Ivoire (1).

APFNP: Association des Propriétaires de Forêts Naturelles et Plantations (Côte d'Ivoire). CIFOR: Center for International Forestry Research (Cameroon). COMIFAC: Central African Commission on Forests (Cameroon). CSRS: Centre Suisse de Recherches Scientifiques (Côte d'Ivoire). FAO: United Nations Food and Agricultural Organization (DRC). FTME: Forêts des Marais Tanoé-Ehy (Côte d'Ivoire). IITA: International Institute of Tropical Agriculture (Cameroon). IUCN: International Union for Conservation of Nature (Cameroon and Burkina Faso). MRU: Mano River Union (Côte d'Ivoire Branch). SFID: Société Forestière et Industrièlle de Djoum (Cameroon). WCS: Wildlife Conservation Society (Madagascar). WWF: World Wildlife Fund (Cameroon, DRC and Madagascar)

In order to facilitate analysis, respondents were requested to select no more than 5 forest / climate change related ideas with preference for those most likely to fulfill adaptation and mitigation objectives. This was based on (a) their knowledge of forest and climate change related strategies generally, (b) knowledge of their countries' NDCs' specifically and (c) explanations on adaptation, mitigation and the project ideas provided by the researcher.

Out of the 85 respondents from 34 institutions or agencies who were contacted and declared availability to participate in the whole study, 53 from 31 institutions or agencies accepted to attend to the current adaptation / mitigation research area (Table 1). Notwithstanding respondents' willingness to get involved, their selection of project ideas likely to enshrine both adaptation and mitigation outcomes was in most cases only made after substantial explanations by the researcher. It was during such explanations that it became evident that project ideas in national planning documents should be written clearly to guide the development of project concepts and fundraising proposals. Table 1 provides information on the number of institutions or agencies involved in the study (affiliation - column 1) as well as the number of respondents interviewed for each institution or agency in parenthesis - column 3.

Abbreviations on Table 1 are explained underneath the Table, with specifications on the country locations of the agencies of respondents. The research was skewed in favour of more representatives from government agencies. This was because of their knowledge and familiarity with the NDC process. Forestry departments in each of the five countries visited, provided two questionnaire responses albeit the tendency to harmonize to one response. This tendency was similar in the departments of environment (Sustainable Development) / Climate Change, which entertained close relationship with Forestry departments in terms of NDC development, where two questionnaire responses were equally provided by climate change agency units. Exchanges with the ministerial departments of agriculture and water/hydraulics were not very fruitful. There was portrayed limited familiarity with the NDC process, which may have been due to NDC preparatory work in some cases, undertaken by consultants based on information from several sectors and in other cases, assigned to one unit for development such as the INDC support facilities of some countries. Consequently, only one response was received from agricultural departments and another one from water/hydraulics departments, represented by Madagascar and Côte d'Ivoire respectively. Apart from government agencies in Cameroon, RDC, Madagascar and the environment / climate change / and water / hydraulics departments of Côte d'Ivoire, where responses were filled and submitted in person to the researcher, those from other government agencies i.e. Burkina Faso and Côte d'Ivoire (Forestry) were sent by e-mail after further explanations on Skype by the researcher. Government agencies provided 22 responses, which comparatively were the most complete among the 31 institutional responses.

Except for COMIFAC and the MRU among intergovernmental organizations where responses were obtained directly by the researcher, those of the Africa Great Green Wall for the Sahara and Sahel Initiative of Burkina Faso were sent by email after further explanations on the data prioritization process by the researcher on Skype. Intergovernmental organizations provided a total of 4 responses. Research organizations represented by CIFOR and IITA in Cameroon shared

their responses during working sessions with the researcher, while the CSRS project personnel in Côte d'Ivoire shared responses by email through their 'Association Inter-Villageoise pour la Gestion de la Forêt des Marais Tanoé-Ehy (AIVG)' Nouamou network. Research organizations provided a total of 6 responses. International organizations contacted provided responses during working sessions with the researcher. FAO was represented by the organization's national consultant and its UN REDD teledetection/aerial photography specialist both in the DRC. International organizations provided a total of 8 responses. Civil society, community organizations including municipal authorities were only available in Burkina Faso (Boni municipality), Cameroon (Djoum / Ngoyla Mintom) and Côte d'Ivoire (Nouamou), from whom a total of 8 responses were received through direct working sessions with the researcher. The private sector provided 5 responses through direct working sessions with the researcher in Burkina Faso, Côte d'Ivoire and Cameroon.

Analysis of responses involved a qualitative approach and a quantitative data comparison process. An effort to enhance reliability was pursued through the use of (a) adequate, systematic and sequential documentation during the data collection, (b) development of a verifiable data base, and (c) use of triangulation and clarifications during exchanges on Skype. The 26 collated project ideas and their shortened variables are presented in Table 2.

TABLE 2 *Twenty-six (26) project ideas and their reduced categories/variables*

Forest and climate change project ideas	Variable
1- Undertake actions to obtain savings from wood energy by promoting improved carbonization techniques and efficient wood energy-saving stoves	1- Wood energy savings
2- Build and promote bio-digesters that employ timber residue and biomass wastes	2- Promote bio-digesters
3- Promote the production and use of biofuels	3- Promote biodiesel production
4- Develop the national REDD-plus policy and strategy	4- Develop REDD+ strategy
5- Strengthen pilot projects that contribute to the implementation of the REDD+ national strategy	5- Implement REDD+
6- Develop the legal and institutional framework for implementing REDD+	6- Develop REDD+ framework
7- Improve the funding mechanism for implementing REDD+	7- Pursue REDD+ funding
8- Build capacity of communities in income-generating activities linked to the sustainable management of forests,	8- Alternative community incomes
9- Develop and test scenarios for registration of community forests	9- Register community forests
10- Develop and promote partnerships between community forests within and outside of the country	10- Community forest partnerships
11- Strengthen capacity of communities and municipal councils in the establishment of Community / communal forests.	11- Promote Communal /community forests
12- Sustainably reconstitute, arrange and manage the forests on rural lands	12- Arrange rural forests
13- Sustainably reconstitute, arrange and manage the forests on the permanently held State-owned lands	13- Arrange state forests
14- Undertake large-scale reforestation programs	14- Pursue reforestation
15- Pursue creation of new forests (afforestation)	15- Pursue afforestation
16- Pursue restoration of degraded forests	16- Forest landscape restoration
17- Pursue enrichment of existing forests	17- Forest enrichment planting
18- Promote reconstitution of the forest cover especially in sensitive areas such as head-waters and river banks	18- Restore sensitive landscapes
19- Promote techniques for improving carbon sequestration by forests	19- Improve carbon sequestration
20- Improve management of protected areas using biodiversity management plans	20- PA management
21- Creation and management of conservation concessions	21- Conservation concessions
22- Promote the large-scale adoption of agroforestry	22- Promote agroforestry
23- Develop sustainable farming schemes	23- Promote sustainable farming schemes
24- Multiply forage seeds and popularize them in grazing regions	24- Promote silvi-pastoral schemes
25- Reduce the extraction of forest timber	25- Reduce timber extraction
26- Improve the management of wild forest fires	26- Wildfire management

The 53 respondents of this research made between 2 and 5 selections from the list of 26 project ideas most likely to satisfy both forest related climate change adaptation and mitigation objectives. More specifically, 3 respondents made 5 priority project idea selections, 5 made 4 priority idea selections, 43 made 3 project idea selections while 2 respondents made 2 project idea selections each. These added up to 168 selections. The number of selections received for each of the 26 project ideas were compared, and the 10 with highest number of selections were refined, and each described in relation to how it fulfilled both adaptation and mitigation objectives. The first 10 prioritized project ideas were selected for refinement because together they contained the major forest and climate change related themes. In order to facilitate comparison, the ideas were reduced as presented on Table 3.

Also, in order to reduce variability mainly in cases where similar project ideas were found in the same country documents, 6 of the 26 project ideas were reduced to three i.e. agroforestry merged with silvi-pastoral schemes; afforestation merged with reforestation; and forest landscape restoration merged with restoration of sensitive sites. These were then coded along with the others. The coded themes were each assigned their number of selections from the responses of respondents (in parenthesis) as presented in the Table 3. It should be indicated that REDD+ project ideas were rarely more than 1 in the different national planning documents mainly because countries were at different stages of the REDD+ process.

Table 3 facilitated development of a graph, with trends depicting the least to the most relevant project ideas likely to address both forest related climate change adaptation and mitigation objectives.

RESULTS

Analysis of research results revealed project ideas in decreasing order of relevance for dual adaptation / mitigation projects, as follows; wood energy savings, reforestation and afforestation, promotion of sustainable farming schemes (agroforestry), promotion of communal and community forests, promotion of bio-digesters, wildfire management, promotion of agro-silvi-pastoral schemes, forest landscape restoration, arrangement of rural forests, promotion of biodiesel production, implement REDD+, forest enrichment planting, reduce timber extraction, conservation concessions, improve carbon sequestration, protected area (PA) management, arrange state forests, pursue REDD+ funding, develop REDD+ framework, develop REDD+ strategy, alternative community income, community forest partnerships, and register community forests. All project ideas are presented in Figure 1 revealing a priority trend towards fulfilling both adaptation and mitigation outcomes.

The first 10 project ideas were rewritten as project titles likely to enshrine both adaptation and mitigation outcomes. This exercise was justified by the level of effort deployed by the researcher in explaining the adaptation and mitigation potential of project ideas to respondents. The rewritten project ideas / titles include key participatory notions and phrases such as; 'local knowledge', 'social infrastructure', environmentally friendly, 'socially-acceptable', 'cultural perceptions' etc. When captured in the title, such notions have the potential to transform a climate change mitigation venture to an integrated adaptation and mitigation pathway. Table 4 presents the ideas rewritten as project titles.

DISCUSSIONS

The study advocating synergy between forest-based climate change adaptation and mitigation through comprehensive project design (Chia *et al*. 2016) recommended among others that development of such projects should be guided by the results of baseline studies, expected to reveal anticipated adaptation and mitigation outcomes. This study on pathways for harmonizing forest-related climate change adaptation and mitigation is located upfront of baseline studies and project design. Based on interactions with respondents, it was evident that comprehensively written project titles have the potential to provide preliminary guidance for the development of terms of references of baseline studies as well as project design. This is important as experts proposing project ideas may not be the same persons responsible for transforming such ideas into terms of references for baseline studies or project concepts.

The first 10 project titles and pathways are assessed and discussed below in terms of their compliance and fit as both adaptation and mitigation interventions.

TABLE 3 *Project ideas with number of selections in parenthesis*

Wood energy savings (18)	Arrange rural forests (8)	Arrange state forests (4)
Reforestation and afforestation (17)	Promote biodiesel production (8)	Pursue REDD+ funding (3)
Promote sustainable farming schemes (15)	Implement REDD+ (6)	Develop REDD+ framework (3)
Promote Communal/community forests (13)	Forest enrichment planting (6)	Develop REDD+ strategy (3)
Promote bio-digesters (12)	Reduce timber extraction (5)	Alternative community income (1)
Wildfire management (12)	Conservation concessions (5)	Community forest partnerships (1)
Promote agro-silvi-pastoralism (10)	Improve carbon sequestration (5)	Register community forests (1)
Forest landscape restoration (9)	PA management (3)	

FIGURE 1 *Ranking of project ideas likely to produce both adaptation and mitigation outcomes*

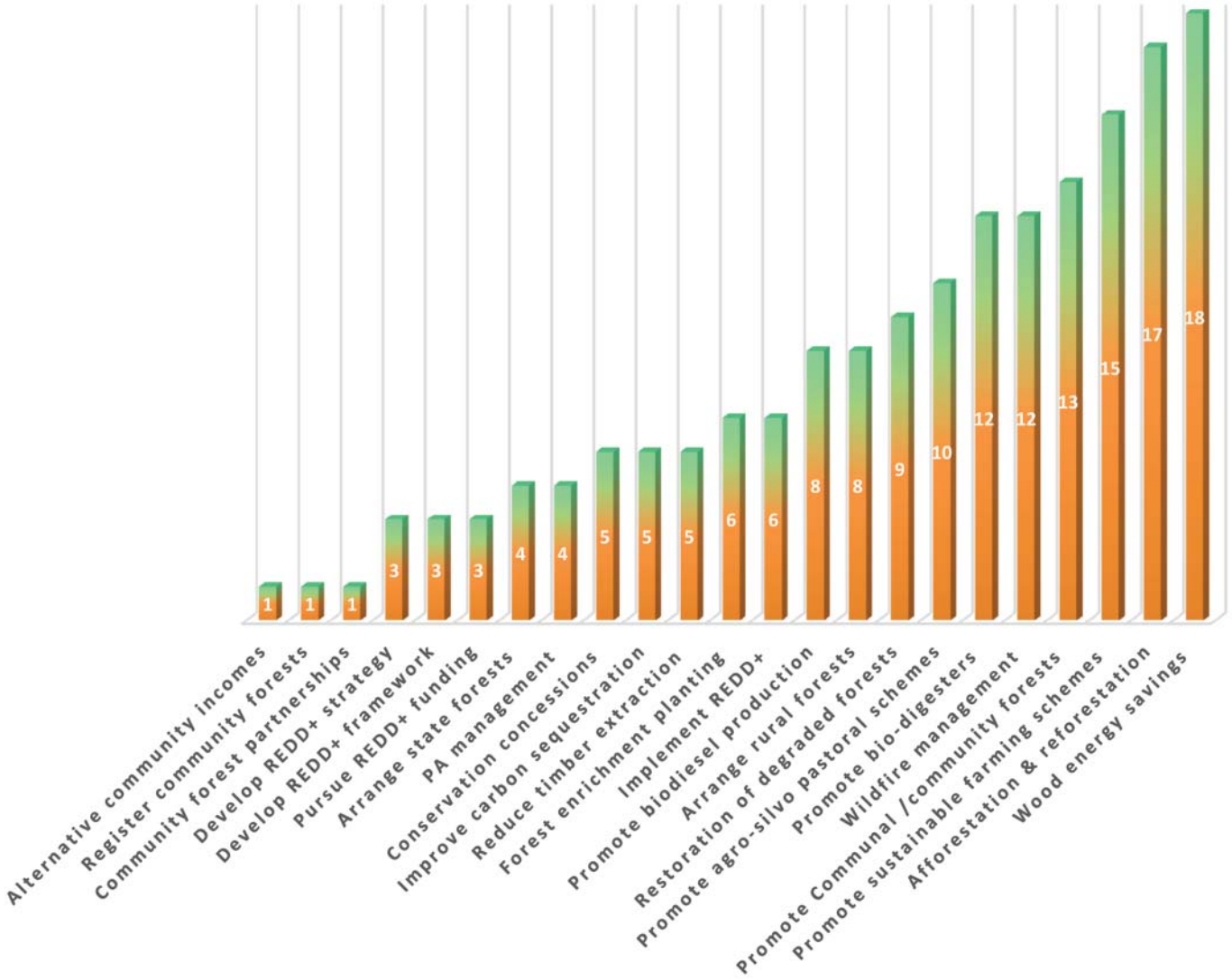


TABLE 4 *Rewritten forms of top ten adaptation and mitigation project ideas*

Most selected adaptation and mitigation project ideas	Proposed title of project ideas
- Wood energy savings	- Carbonization for charcoal production using improved and innovative methods
- Reforestation and afforestation	- Large-scale / local level afforestation and reforestation programs through community involvement
- Promote sustainable farming schemes	- Development of sustainable farming schemes based on local knowledge and research outputs
- Promote Communal/community forests	- Development of urban forestry schemes using socially acceptable species
- Promote bio-digesters	- Development of bio-digesters around high timber and agricultural residue centers
- Wildfire management	- Improvement of management of forest fires through the use of appropriate social infrastructure
- Promote agro-silvi-pastoralism	- Promotion of agro-silvi-pastoral schemes based on local knowledge and research outputs
- Forest landscape restoration	- Restoration of degraded forest land using adapted tree species
- Arrange rural forests	- Development of communal and community forests based on climate friendly land-use plans
- Promote biodiesel production	- Production of biofuels (bio-oils or bio-ethanol) in a socially and environmentally friendly manner

Carbonization for charcoal production using improved and innovative methods

More than half of households in Sub-Saharan (francophone) Africa depend on wood for cooking energy (FAO 2011). For example, in Burkina Faso, biomass accounts for 85% of energy consumption, ahead of petroleum products – 14% and hydroelectricity – only 1% (SP-CONEDD 2009). Cutting trees for the supply of domestic energy is therefore almost inevitable. Making charcoal involves the near anaerobic combustion of wood to produce coal, liable to last longer than firewood to produce cooking energy in households. Generally, in moist forest countries, charcoal making is usually undertaken close to and associated with the opening of new farms or mature fallows (researcher's observations between South West Côte d'Ivoire and South East Liberia). Instead of burning standing trees as farms are opened, carbonization for charcoal production in such settings has the advantage of reducing the quantity of carbon dioxide released from the agricultural scheme. In this regard, carbonization is a mitigation activity if the process is efficient in converting firewood to charcoal. However, traditional carbonization kilns that consist of burning wood underneath soil and thatch mounds only account for an efficiency rate of about 18% i.e. 5.5 kg of wood yielding 1 kg of charcoal (Sow 1990).

There are other forms of kilns with higher conversion rates. Brick kilns are common in drier countries such as Burkina Faso and entertain a conversion rate of up to 50%. Others, such as the Mekko kiln, made of a durable metal casing have a higher conversion rate as they conserve most wood by-products during combustion with a wood to charcoal conversion rate upwards of 75% (Kalenda *et al*. 2007). As forests and trees become scarce in the face of increasing population, exacerbating poverty, coupled with the negative effects of climate change, carbonation for charcoal in improved kilns constitutes a coping strategy and therefore a climate change adaptation approach to produce cooking energy as long as it is accompanied by planned and sustainably managed reforestation projects. Carbonization for charcoal production using improved kilns is consequently a mitigation and adaptation scheme under this premise.

Large-scale / local level afforestation and reforestation programs through community involvement

Afforestation is essentially tree planting on land which was not 'formerly' forested, even as reforestation refers to tree planting on recently cleared land i.e. prior to 1990 (Mizuno 2007). As an example, degraded land can be restored or reforested as a project within the Kyoto Protocol's Clean Development Mechanism (CDM) scheme. Within this framework, reforestation activities are expected to justify that land for the activity entertains forests within the thresholds adopted for the definition of forest by the host country (Mizuno 2007). They include all young natural forest stands and plantations on the target land that are not expected to be at the level of the minimum crown cover and minimum height chosen by the host country to define a forest (Mizuno 2007). Also, justifications must be provided that the land has not been temporarily un-stocked as a result of human interventions such as harvesting or through natural causes before 1990. For afforestation more specifically, activities are expected to demonstrate that within a period of at least 50 years, the vegetation on the land has been below the thresholds of a forest, as defined and adopted by the hosting country (Mizuno 2007). Afforestation and reforestation constitute typical mitigation activities since they expand carbon sinks by accumulating and immobilizing carbon.

Afforestation and reforestation together with minimum tree cutting strategies have been employed in some African countries as coping strategies to buffer the negative effects of climate change (Paul *et al*. 2013). Examples include but are not limited to; minimum cutting and adapted reforestation to reduce the drying-up of water sources due to drought around several head-waters of the Fouta Djallon highlands of Guinea – the water tower of West Africa; adapted reforestation to reduce the incidence of landslides along slopes as practiced on the Cameroon mountains, where municipal / council forests protect slopes from landslides. Such activities imply both reactive and anticipatory adaptation. Local level afforestation and reforestation ventures can consequently be classified as both mitigation and adaptation schemes. Moreover, it is also a mitigation venture when wood harvested from acknowledged afforestation and reforestation schemes is used as substitute for products that require high energy for their production such as iron, steel, aluminum, plastics, and reinforced concrete. Such wood should, however, be replaced through reforestation in order to pursue sustainable forest management outcomes.

Development of urban forestry schemes using socially acceptable species

Urban forestry schemes are tree and shrub planting ventures in public places, constituting one of the most stable tree-based systems, capable of lasting several decades. Such schemes serve the purposes of research and education, recreation and tourism, scenic beauty, shade, windbreaks, cultural and spiritual purposes, and for the provision of non-timber forest products. Due to their stability, urban forestry schemes constitute a viable mitigation option, sequestering and immobilizing carbon for several decades. However, they also serve as the 'lungs' of urban townships where their presence has the additional function of tempering the immediate negative effects of climate change. This microclimatic function is most evident in botanical gardens, urban floral sanctuaries and township parks. Urban forestry schemes can therefore also be classified as a viable adaptation option.

Restoration of degraded forest land using adapted tree species

The restoration of degraded forest landscapes is usually undertaken among other aims, to alleviate the current and future negative impacts of climate and anthropogenic catastrophes (FAO-UNASYLVA 2016). Examples from the

FIGURE 2 *Young Jatropha biofuel plantation mixed with onion – Burkina Faso*

Source: Photograph by Martin Nganje (2009)

researcher's field observations, include; the restoration of some coastlines and deltas degraded by the negative effects of climate change and over-cutting of trees for fish drying by fishing communities in Senegal, Côte d'Ivoire and Cameroon with mangroves species; sites degraded by mining such as the abandoned artisanal mining sites around the Tinkisso – Siguiri industrial mining complex in Guinea by civil society effort using indigenous tree species; restoration of landscapes degraded by refugees and displaced people such as between North West Burkina Faso and Mali with improved and adapted tree species; forest land degraded by erosive floods or extensive wild fires with locally adapted tree species; clear-felled forests restored with improved tree species etc. The landscape restoration scheme is evidently a mitigation venture by virtue of its ability to sequester and immobilize carbon. It is also an adaptation scheme when pursued in reaction to the negative impacts of climate forces such as eroded coastlines and landscapes decimated by wildfires, as well as in relation to anticipated climate and man-induced activities that lead to mudslides after resource extraction operations such as mining.

Production of biofuels (bio-oils or bio-ethanol) in a socially and environmentally friendly manner

This scheme involves planting trees and shrubs whose products are used in the production of biofuel such as diesel. Species already in use include; the Oil Palm (*Elaeis guineensis*) and Jatropha (*Jatropha curcas*) – Figure 2. With increasing population on limited land resources, this scheme currently generates a lot of debate in relation to its impact on food security and food prices (Popoola *et al*. 2015). However, biofuels are advantageous over fossil fuels in that they require less energy for their production and therefore release less greenhouse gases into the atmosphere in this regard. Also, because biofuels are produced from biomass and consequently renewable sources, they are carbon neutral when accompanied by the continuous planting of tree stocks to sequester carbon dioxide released by biofuel use. Under these conditions biofuel production and use constitutes a mitigation venture. It is also a coping strategy and thus an adaptation scheme as it provides an opportunity for rural poor communities and land-locked countries such as those of the Sahel to reduce their dependence on expensive fossil fuel, transported through thousands of kilometers on risk-prone roads, to eventually produce their own fuel for the operation of equipment ranging from local mills to motor-cars. NEPAD recommends that bankable biofuel projects should preferably be public, private partnerships – PPPs (NEPAD/UNEP 2003).

Development of sustainable farming schemes based on local knowledge and research outputs

Sustainable farming is advocated as responsive to the conservation of soils, forests and forest biodiversity. An exemplary case is cocoa agro-forests, which are a mix of cocoa trees,

occasional perennial shade trees and annual crops of cassava and bananas as practiced in western Côte d'Ivoire and southern Cameroon. If the stocking rates from research results such as provided by the International Institute of Tropical Agriculture (IITA) are followed (Gockowski and Sonwa 2010), this pattern has the potential to provide multiple revenue benefits and livelihood support to its promoters, while entertaining the possibility of viable carbon sequestration through its cocoa stands and shade trees. Sustainable farming schemes are also practiced in dry forest landscapes such as in Niger's Dan Saga communities where millet and sorghum farmers have discovered that minimum soil tillage privileges the sprouting of roots of trees, cut decades ago. The un-ploughed land and trees tendered to flourish on farms hold the soil firm against crop seed loss to wind erosion (Pye-Smith 2013). The scheme is consequently a viable mitigation option as well as a climate change adaptation venture.

Development of bio-digesters around high timber and agricultural residue centers

Bio-digesters anaerobically degrade biomass to produce gases, mainly methane, highly desired as a domestic fuel in cooking. This scheme uses the waste from timber processing units and the residue from industrial agricultural plants as well as from other sources to produce methane gas. Because bio-digesters essentially employ biomass wastes, habitually burnt as a way of their disposal, they consequently ensure a reduction in the use of firewood (released for carbon sequestration) and consequently reduce the quantity of carbon-dioxide released into the atmosphere. In this regard, the scheme is a mitigation venture. Bio-digesters can also be labeled as a coping and consequently an adaptation strategy as they promote the use of wastes in the face of dwindling and scarcer forest resources needed for the supply of domestic energy.

Development of communal and community forests based on climate change friendly land-use plans

Several African countries have enacted legislation for the decentralization and decongestion of natural resources management. While there are teething problems in most of these countries in terms of the effective devolution of powers for the management of forests, it is envisaged that devolution will become effective as the management capacity of decentralized authorities and communities is enhanced. Notwithstanding, several of such forests administered based on simple management plans exist already. An example includes the community managed 'Forêts des Marais Tanoé-Ehy' in Côte d'Ivoire, visited during this study, managed by officially recognized decentralized instances. The forest appeared secure, due to the element of proximity control and oversight provided by village community residents. The security of such forests makes them a useful carbon sink and consequently a viable mitigation venture. They also provide a pool of resources such as medicinal and aromatic products (MAPs) and a variety of non-timber forest products as safety-nets to community residents. In this regard, the scheme is also a viable climate change adaptation option.

Promotion of agro-silvi-pastoral schemes based on local knowledge and research outputs

Fodder trees have the potential to modify the microclimate in drought-prone pasturelands, into graze friendly rangelands. Research conducted in the early 2000s in Niger found that *Faidherbia albida* was one among other fodder species that can be promoted on pastures as well as in agroforestry schemes as a soil fertilizer during the cropping cycle (Kho *et al*. 2001). The species, among other characteristics has been proven to be versatile in the face of drought and wild fires, entertaining minimal effects on soil water recharge and least tendency to compete with food crops (Kho *et al*. 2001). Based on local knowledge from rangeland residents on the most resistant waterholes, such tree species (with minimal effects on soil water recharge) can be introduced around such sites from where they spread outwards. Because of the drought and wildfire resistant ability of these parkland species and the local interest to protect them, this scheme provides an opportunity for carbon sequestration and consequently a viable mitigation option. The scheme equally provides community residents with a multiplicity of goods and services, including; NTFPs, fuel-wood, fodder and other products to help withstand the negative effects of climate change, thereby also making it an outstanding climate change adaptation option.

Improvement of management of forest fires using appropriate social infrastructure

Fire is an important land management tool (Rarivomanana 2017). However, when unmonitored, it can decimate thousands of hectares of standing forests while ruining their related functional ecological processes. Adequate fire management produces direct benefits to neighboring communities in comparison to the unmanaged condition. It has been revealed from forest fire projects that, wherever people have a direct interest in protecting their natural resources and effectively do so, unplanned wildfires will be reduced (Ministry of Foreign Affairs - Finland 2007). In such cases, communities will mobilize themselves to prevent wildfires when they acknowledge that by so doing, they will benefit in safeguarding their natural resources, and consequently their livelihood. With adequate mobilization through the setting-up of formal or informal social groups such as community fire squads or brigades also involved in forest restoration or reforestation in community forests or government production forests, this scheme can contribute in reducing the loss of tree-based carbon, thereby constituting a veritable mitigation option. The setting-up of social infrastructure to fight forest fires in anticipation of the risks that are usually associated with such fires also constitutes a climate change adaptation option.

CONCLUSION

During this study, it was noted that the way in which project ideas were written and presented in NDCs and related national documents provided little guidance on whether they could enshrine climate change adaptation and or mitigation. Such ideas ought to be written as clearly as possible in the form of project titles since there is little chance that those who propose them will be the same persons to develop them into terms of references for baseline studies or into project concepts. Inadequately written project titles are likely to lead to unintended initiatives and outcomes. A well-developed project title also enshrines method or strategy and therefore a project underway.

The 10 prioritized project titles chosen based on the number of selections received from respondents, expanded and described in this paper highlight project level linkages between forest-based climate change adaptation and mitigation. As pathways for harmonizing forest related climate change adaptation and mitigation, they can be adopted or adapted for implementation in forest-related climate initiatives, including REDD+ pilot projects. More than one of the pathways can be combined on the landscape to fulfill multiple climate change adaptation and mitigation functions.

While it is possible to develop forest-related mitigation-only or separate adaptation and mitigation initiatives, those that enshrine both adaptation and mitigation outcomes have the potential to take account of the reality of poverty, lack of expertise and inadequate experience in Sub-Saharan francophone African institutions at all levels. It is therefore more profitable to integrate adaptation and mitigation frameworks at least to benefit from the mutual results from both approaches. If the integrated approach is sought, care should be taken to conceive initiatives so that they portray this orientation from the outset. Key participatory notions and phrases such as; 'local knowledge', 'social infrastructure', environmentally friendly, 'socially-acceptable', 'cultural perceptions' etc., when captured on the project title, have the tendency to transform a climate change mitigation venture to an integrated adaptation and mitigation pathway.

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An overview of the development of the woodfuel industry in southern Africa: opportunities and challenges

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SUMMARY

The ever-changing niche of the woodfuel industry in the economies of countries in southern Africa forms one of the backbones for accelerated socio-economic development. This study sought to evaluate linkages between factors influencing production, consumption, commercialisation and sustainability of the industry. The sub-region is not bereft of the requisite threshold of expertise, research outputs, approaches and policies, coordinating frameworks and other means for rapid cross-border learning from successful examples of a more organised and regulated sustainable development. In addition, the region needs 'repeated, louder drumming' of recommendations from researchers, using new and available information generated from various studies to jolt policy-makers into action. The full potential of the fuelwood industry to transform the socio-economic fortunes of the sub-region rests on creating a legal and policy framework that frees production, consumption and commercialisation restrictions by promoting sustainable, well-organised and coordinated systems.

Keywords: fuelwood, production, consumption, trade, regional integration

Une vue d'ensemble du développement de l'industrie du bois de combustion dans les pays du sud de l'Afrique: défis et opportunités

D. KAYAMBAZINTHU et V.O. OEBA

La niche constamment changeante de l'industrie du bois de combustion dans les économies du sud de l'Afrique est une partie de la colonne vertébrale soutenant un développement socio-économique accéléré. Cette étude s'est efforcée d'évaluer les liens entre les divers facteurs influençant la production, la consommation, la commercialisation et la durabilité de l'industrie. La région du sud n'est pas en carence du seuil requis d'expertise, de sorties de recherche, d'approche et de cadres de coordination de politiques et d'autres moyens d'accélérer les apprentissages glanés d'exemples à succès d'un développement durable mieux organisé et réglementé au-delà des frontières. De plus, la région a besoin d'une répétition appuyée de recommandations des chercheurs, en utilisant l'information nouvelle et disponible provenant de diverses études pour pousser les créateurs de politique à l'action. Le potentiel complet que possède l'industrie du bois de combustion à transformer les fortunes socio-économiques de la région sud repose sur la création d'un cadre politique et légal libérant les restrictions de la production, de la consommation et de la commercialisation en promouvant des systèmes coordonnés durables et bien organisés.

Sinopsis del desarrollo del sector de la leña en el sur de África: oportunidades y desafíos

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El nicho en constante movimiento del sector de la leña en las economías de los países del sur de África constituye uno de los pilares del desarrollo socioeconómico acelerado. El objeto de este estudio fue evaluar los vínculos entre los factores que influyen en la producción, el consumo, la comercialización y la sostenibilidad de este sector. La subregión no carece del umbral necesario de experiencia, resultados de investigación, enfoques y políticas, marcos de coordinación y otros medios para acelerar el aprendizaje transfronterizo a partir de ejemplos exitosos de un desarrollo sostenible más organizado y regulado. Además, la región necesita "alzar la voz y seguir machacando" las recomendaciones de los investigadores mediante el uso de la nueva información disponible generada a partir de varios estudios para que los responsables de la formulación de políticas pasen a la acción. El pleno potencial del sector de la leña para transformar el destino socioeconómico de la subregión reside en la creación de un marco jurídico y político que libere las restricciones a la producción, el consumo y la comercialización mediante la promoción de sistemas sostenibles, bien organizados y coordinados.

INTRODUCTION

Fuelwood, a collective term for charcoal and firewood, is a major source of cooking and heating energy for most urban households in Sub-Saharan Africa (SSA) (FAO 2010). While it constitutes a primary extractive industry and one of the major drivers of deforestation and forest degradation impacting on the environment and climate change, its production, commercialisation and consumption is undoubtedly key to the socio-economic development of countries in southern Africa. Fuelwood is mostly produced in rural areas, close to urban centres, but largely consumed in urban to peri-urban areas (Chidumayo 1997, Kambewa *et al*. 2007, WWF 2010, GRZ 2010, Yaron *et al*. 2011, Nyembe 2011, Gumbo *et al*. 2013). For example, in Zambia, Malawi and Madagascar, 85%, 45%, and 90% of the predominantly poor urban to peri-urban households respectively rely exclusively on this energy source. This is not surprising considering that charcoal in the region is relatively cheap when compared with electricity and petroleum-based fuels, which works well for the low income urban to peri-urban households (Hibajene and Kaweme 1993, Kambewa *et al*. 2007). In addition, the impetus for continued overreliance and growth in urban demand for this form of energy, leading to its increased production, commercialisation and consumption, appears solidly founded in its contribution to national economies by providing household incomes, tax revenues and employment along its value chain. Trossero (2002), reported that this is true not only for the southern African region but also for most developing countries.

While such positive attributes may seem to complement socio-economic development efforts of the region, the fuelwood extractive industry has, regrettably, been associated with causing environmental degradation, negative health and climate change impacts (Chidumayo 2010, LTSI 2015). For example, in the charcoal production process in most of the traditional kilns used, only 35% of available wood carbon is fixed in charcoal, the rest is released into the atmosphere as smoke and non-condensed gases such as carbon dioxide, carbon monoxide, methane and other harmful gases (Hibajene and Kalumiana 2003, Chidumayo 2010). Apart from emitting such harmful greenhouse gases, only between 10% and 20% of wood used in charcoal production is actually converted into charcoal (Makungwa 1997, Openshaw 1997, Pereira *et al*. 2001, Mugo and Ong 2006, ETFRN 2014). It is precisely these low rates of conversion efficiencies that result in vast areas of forest being lost for small gains in the amount of charcoal produced. Thus in Zambia, for example, an estimated 5 to 10 tons of wood is needed to produce a ton of charcoal, irrespective of the area cleared and effects on the ecosystem (Chidumayo 2010).

Drawing on investigations from the region, fuelwood especially charcoal production, is thus taken together with agricultural expansion, as the most important drivers of deforestation and forest degradation in the region, with other prevailing drivers being unsustainable logging practices, infrastructure development, population growth and uncontrolled frequent and very late fires (Yaron *et al.* 2010, Chittock 2010, Chidumayo and Gumbo 2013, Gondo 2013, LTSI 2015). Though the magnitude of impact varies considerably in the region, these drivers are linked to a number of issues, including policy and legislative.

In view of the above-outlined impacts, periodic reviews to establish the extent and importance of fuelwood production, commercialisation and consumption is appropriate as a basis for sustainable development of the fuelwood industry in southern Africa. Similarly, a periodic determination of the extent and impact of this extractive industry on the environment and climate change would be equally important in understanding the food-fuel-fibre production systems, vital for socio-economic development of the region. This is particularly relevant in view of past work done in Africa which suggests, for example, that most charcoal production on the continent constitutes unsustainable forest mining of existing natural woodland stocks, with most countries being ill prepared for the challenges which essentially undermine charcoal's poverty-reduction potential and its other important attributes (Zulu and Richardson 2013).

This paper analyses trends in fuelwood production, commercialisation and consumption in a few selected countries in southern Africa. It also addresses related impacts due to deforestation and energy needs as well as prevailing woodfuel policies, with the view to revisit and provide appropriate key recommendations for the sustainable development of fuelwood industry in southern Africa.

METHODOLOGY

This study draws on methodologies from the second phase of a project entitled "African Forests, People and Climate Change" implemented by the African Forest Forum (AFF) with the objectives to improve knowledge and capacity of African stakeholders in managing forests and landscapes in the context of climate change and to inform and contribute to the shaping of policies and initiatives relevant to forests and climate change. Through these objectives, the project aims to enhance the role of African forestry and its contribution to adaptation to the adverse effects of climate change in various landscapes, and in ways that will improve livelihoods, sustain biodiversity and the quality of the environment, in addition to strengthening the capacity of Africa's forests to adapt to climate change and to contribute to mitigation efforts. As part of its work plan AFF identified four sub-regions, namely, West Africa and Sahel, Central Africa, Eastern Africa and Southern Africa to undertake in depth studies in some selected countries in the different regional economic communities on policies and other issues on the 3Fs nexus (food-fuel-fibre) in the context of climate change in Africa, and building on earlier studies undertaken by the AFF. For the Southern African Region, the in-depth studies in selected countries of Malawi, Zambia, Zimbabwe and Madagascar were premised on the assumption of the existence of 'differentiated but common' policies, environmental and forestry composition and management, challenges and opportunities with regard to

policies and other issues related to the nexus food-fuel-fibre production. For this reason, individual country perspectives on fuelwood were examined and subsequently brought to bear on what may be obtained from a regional (SADC) stand point.

A baseline survey was undertaken in the selected countries for primary and secondary data collection using semi-structured questionnaire and key informant checklist. Further secondary data and information was obtained from other countries in the sub region using a desk study approach. The main data collected, which also involved reviewing existing literature, regional and country reports, documents on policy and legislation, strategies and plans, focused on production, consumption and commercialisation of fuelwood, covering the years from 1990 to 2010. Key areas of data collection included assessing and documenting the impact of the fuelwood extractive industry, mechanisms supporting production and commercialisation, policies, legislations from relevant government, state actors and non-government agencies, including those related to trade and commerce, fuelwood and charcoal policies and other practices that will make fuelwood and charcoal industry a viable business at national and sub-regional levels; available or proposed strategies to enable an effective and sustainable levels of production and consumption, nationally and regionally.

Particular emphasis was placed on reviewing recent publications by governments, regional bodies and other organisations, such as the Food and Agriculture Organization (FAO). Both quantitative and qualitative analytical approaches were used to generate information in line with the study's objectives. Primary data collection involved country interviews with officials from relevant government agencies, stakeholders from the private sector, non-governmental organisations (NGOs) and national government agencies. On average, the interviews across the four southern Africa countries were conducted over 3 days per country, with a total of 40 officials formally interviewed. These included Directors of Forestry, Environment, Energy, Trade and Industry; Chief Technical Advisors, Country Directors and National Project Coordinators of NGOs, Directors of Planning and Information, Government Policy Coordination Officers, Research Officers, General Managers and Operations Managers of NGOs, Country Coordinators of International Conventions, Development Consultants of NGOs, Environmental Officers, Team Leaders, and field officers.

The major difficulty in data collection across the countries under study was limitation of time, with the result that it was only possible to hold fewer interviews than scheduled. It was also difficult for government officials to discuss and share documents that were regarded as either sensitive, such as those on mining, or those documents that were in the process of formulation and development and therefore for internal use only. In spite of these limitations, the analysis of information from the available documents and interviews from the above listed categories of officials provided a fair overview of policies and other issues related to fuelwood in the southern African region.

RESULTS AND DISCUSSIONS

Production and consumption

According to the United Nations Environmental Programme (UNEP), the socio-economic factors plus the ever-increasing population growth in Africa, imply that the demand for charcoal is likely to double or triple by 2050 (Deccan 2016). A comparative analysis showing increasing global charcoal production by Arnold *et al*. (2006), while showing the existence of geographical differentiation between regions of the world and within Africa (Figure 1), reveals that charcoal consumption in Africa is expected to increase considerably and faster than other regions of the world, doubling by 2030 alongside a 24% increase for firewood. In southern Africa, a similar observation by Gumbo *et al.* (2013) based on an analysis of current economic conditions as well as rapid urbanization in Zambia, showed that the trend in charcoal production and consumption is on the rise. These analyses and others on fuelwood production and consumption (Figure 1, Table 1) reinforce an unequivocal development, giving evidence of a defining future of continued dependence on charcoal as a major source of energy in southern Africa.

As depicted in Table1, annual charcoal consumption in Malawi already more than quadrupled (by >400%) between 1998 and 2011 (Yaron *et al*. 2011), while that of Mozambique (1980–1996) and Zambia (1969–2010) increased five-fold (by 500%) and more than three-fold (367%), respectively. In comparison to the Africa-wide increased consumption which grew by 3% between 2000 and 2010 (Iiyama 2013), these figures for southern Africa, though not exactly of the same timeframe, are quite staggering. Although the driving factors for the growing demand, namely socio-economic factors, ever-increasing population and urbanisation growth rates, may be common to African countries, the big difference in increased consumption indicates that these factors may be more pressing and overwhelming in the southern Africa region. It may, therefore, not be surprising to note how these factors also create significant regional variation in supply and demand of charcoal in SSA, in terms of the degree and rate of fuelwood extraction, with more of it being done in the east and southern African region. Whereas selective cutting and coppicing of favoured species for charcoal is a common practice in West African Sahel, clear cutting or felling of desirable species for charcoal is more prevalent in east and southern Africa. While both practices, to some extent, tend to cause depletion of preferred species and adverse effects on the ecosystem composition and biological productivity, forest cover above 10% is left intact in the West African Sahel region while the species mix and overall volume is reduced, with landscapes often transformed from woodland to bush, and from bush to scrub in east and southern Africa (Iiyama 2013). Clearly, given these levels of consumption, high population growth (at 4.0%, 4.7%, 5.3% and 2.5% for Mozambique, Tanzania, Malawi and Zambia, respectively) and increased urbanisation (at 4.0%, 4.7%, 5.3% and 2.5% for Mozambique, Tanzania, Malawi and Zambia, respectively)

TABLE 1 *Charcoal consumption in selected southern African countries and Africa-wide*

Year	Million tonnes	Country/Region	Source
	Annual consumption		
1969–2010 (31 yrs)	Grew by 367%	Zambia	Gumbo *et al*. 2013, Malambo and Syampungani 2008
1998–2011(12 yrs)	Grew by >400%	Malawi	Yaron *et al*. 2011
1980–1996 (16 yrs)	Grew by 500%	Mozambique	Yaron *et al*. 2011
2000–2010 (10 yrs)	Grew by 3%	Africa-wide	Iiyama 2013

(May-Tobin 2011, Gumbo *et al*. 2013) can only lead to a greater demand for charcoal, implying increased production and consumption in southern Africa. This continued increasing trend, together with its projections, draws a most pertinent question that cannot be ignored and that is how to strategically meet the current and future energy needs of a growing population in the region.

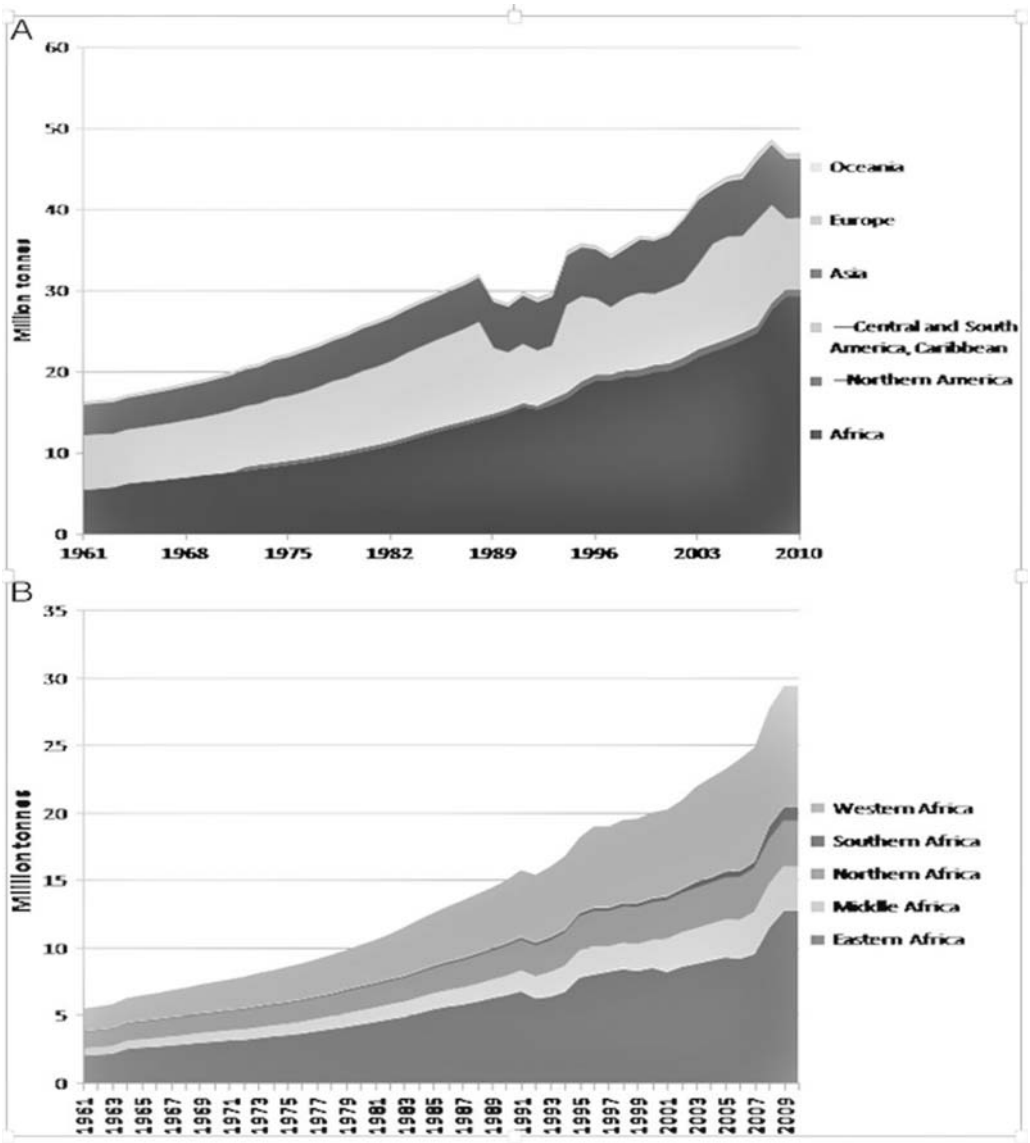
When addressing concerns related to how to strategically meet current and future energy needs of a growing population, the country interviews with various stakeholders tended to focus on the need to find suitable and sustainable alternatives. This gave the perception that the countries were advancing various approaches towards "energy transition" or migration from use of biomass fuels to modern cleaner forms within a country's energy mix, such as petroleum-based alternatives (liquid petroleum gas (LPG) and kerosene) and electricity. In a review of its two instruments for energy infrastructure development, namely the Regional Infrastructure Development Master Plan (RIDMP) (2013–2017) and the Protocol on Energy (1996), SADC (2015) outlines the strategic energy subsectors to include electricity, petroleum and gas, coal, wood and charcoal, nuclear energy, renewable energy and energy efficiency. Of these, electricity was considered the main alternative by the stakeholders although it was regarded as not readily accessible or unaffordable to most people, particularly the poor urban and peri-urban households. Individual country data sets in the region, representing end user electricity tariff increase values (US cents/kWh) (Appendix I) were used to try to understand and verify the issues of accessibility and affordability.

According to Sikwanda (2016), the accessibility and affordability of electricity appears to be generally a function of the energy mix available to a country. Thus, the electricity generation mix has an effect on the average end user electricity tariffs in a country and Figure 2 illustrates this clearly for the southern African region, where the average end user electricity tariffs ranged from USc 3.10/kWh to USc 16.04/kWh in 2015. The United Republic of Tanzania had the highest tariff at USc 16.04/kWh followed by Namibia at USc 15.00/kWh, while Angola had the lowest tariffs at USc 3.10/kWh followed by Zambia at USc 6.00/kWh (RERA 2015).

Invariably, the different end user electricity tariffs depicted in Figure 2 will have varying implications on the levels of exploitation of other available forms of energy, with charcoal and firewood being of central concern for southern Africa. For this reason, and in order to verify the perceived claims made during interviews of the high cost of electricity which was said to force people to continually depend on charcoal and firewood, Figure 3 traces the end user electricity tariff increases from 2000 to 2015. By using the country data sets for Malawi, Zambia and Zimbabwe, representing end user electricity tariff values (USc/kWh) (Appendix I), Figure 3 appears to show an upward surge in electricity tariffs, consistent with increased rates of deforestation. Although this tends to confirm the claims by stakeholders interviewed, the increasing electricity tariffs beyond affordability of most people can only be a part of a larger mix of contributing factors towards continued and unsustainable production and consumption of fuelwood, such as the already noted high population growth and increased urbanisation for Mozambique, Tanzania, Malawi and Zambia. However, the issue of affordability as a factor needs to be investigated in real and not perceived terms to provide evidence that would help governments design, for example, targeted subsidies for the poor. So far the only indications of the increasing electricity tariffs beyond affordability have been exhibited by public outcry and massive protests against the increased tariffs, leading to the revision, reversal or withdrawal of such promulgations. For example, governments through national electricity companies such as the Zambia Electricity Supply Commission (ZESCO), the Tanzania Electricity Supply Commission (TANESCO), the South African Electricity Supply Commission (Eskom) in 2015, 2013 and 2016, respectively backed down on increasing tariffs by 216%, 155% and 16% following such public outcry and protests. Similarly Ghana and Nigeria experienced public outcry and protests in 2016, following tariff increments of 67% and 45%, respectively (Sebbowa 2010). It therefore seems highly suspect that the trends in high population growth, increasing urbanisation and issues regarding electricity tariffs would be the order of the day into the foreseeable future as there appears to be no plausible reason to believe that such scenarios would change in the short to medium term, unless there are drastic measures taken to confront the challenges.

The need for measures to resolve the challenges however calls for judicious consideration of a number of strategic issues in a region dominated by hydroelectricity generation, regarded as one of the cheapest forms of power production compared to thermal and coal. One of the challenges that must be addressed by most SADC countries today is the need to balance the act between access and affordability. According to Cecila and Maria (2001), most policy makers are caught in between balancing the act between cost reflectivity and

FIGURE 1 *Charcoal production by region of the world: 1961–2010 (millions of tonnes). B. Charcoal production by region of Africa: 1961–2010 (millions of tonnes)*

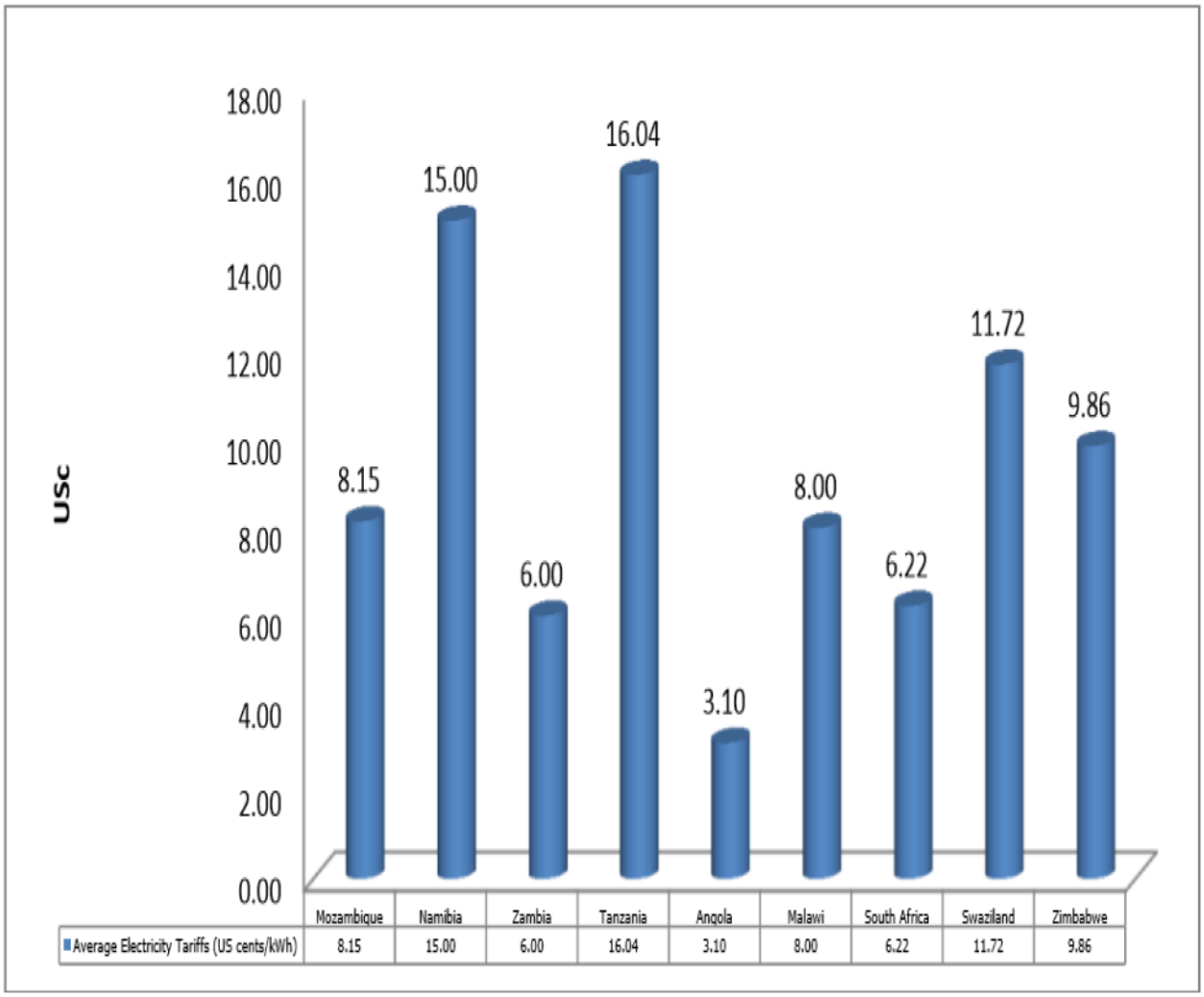


Source: FAOstat (2010). http://faostat.fao.org/site/626/default.aspx#ancor.

affordability. A cost-reflective tariff ensures recovery of all the allowable costs of each regulated and licensed activity within the generation, transmission, distribution and supply value chain and also ensures a reasonable rate of return on investment. As such, regulators must balance the financial sustainability of the sector against the well-being of various segments of society, especially the poor residential customers in determining tariffs. Affordability in the context of electrification and use of electricity means whether or not households can afford to actually use electricity once they are connected to the grid. The cost of electricity for consumers is assessed in relation to household incomes, purchasing power (opportunity costs of other goods) and relative cost of electricity compared with other commodities. In a region where half of the population is estimated to live below the international poverty line of US $ 1 per day, regulators face a stiff challenge in the SADC region as they must decide the tariff rate that would be affordable and yet not making the utility worse off (Sikwanda 2016).

The above plus public resistance towards any migration to cost reflective tariffs (i.e., by increasing tariffs); insufficient investment and aging infrastructure and difficulties in collection of revenues for the electricity delivered are among the other challenges that underpin the problems of accessibility and affordability in Southern Africa (Sebbowa 2010, World Bank 2015, Sikwanda 2016). These challenges whose impact results in use of non-reflective tariffs by countries in the region, except for Namibia and Tanzania (reported to have already achieved cost reflective tariffs), manifest themselves in power deficits leading to load shedding, higher system losses and failure to attract investment (Sikwanda 2016). As a region, SADC has enormous responsibility to curtail political interference in the operations of power utilities, an important factor in transitioning electricity supply industries towards

FIGURE 2 *Average end user electricity tariffs in United States cents (USc) per selected SADC countries in August 2015*



Source: RERA (2015)

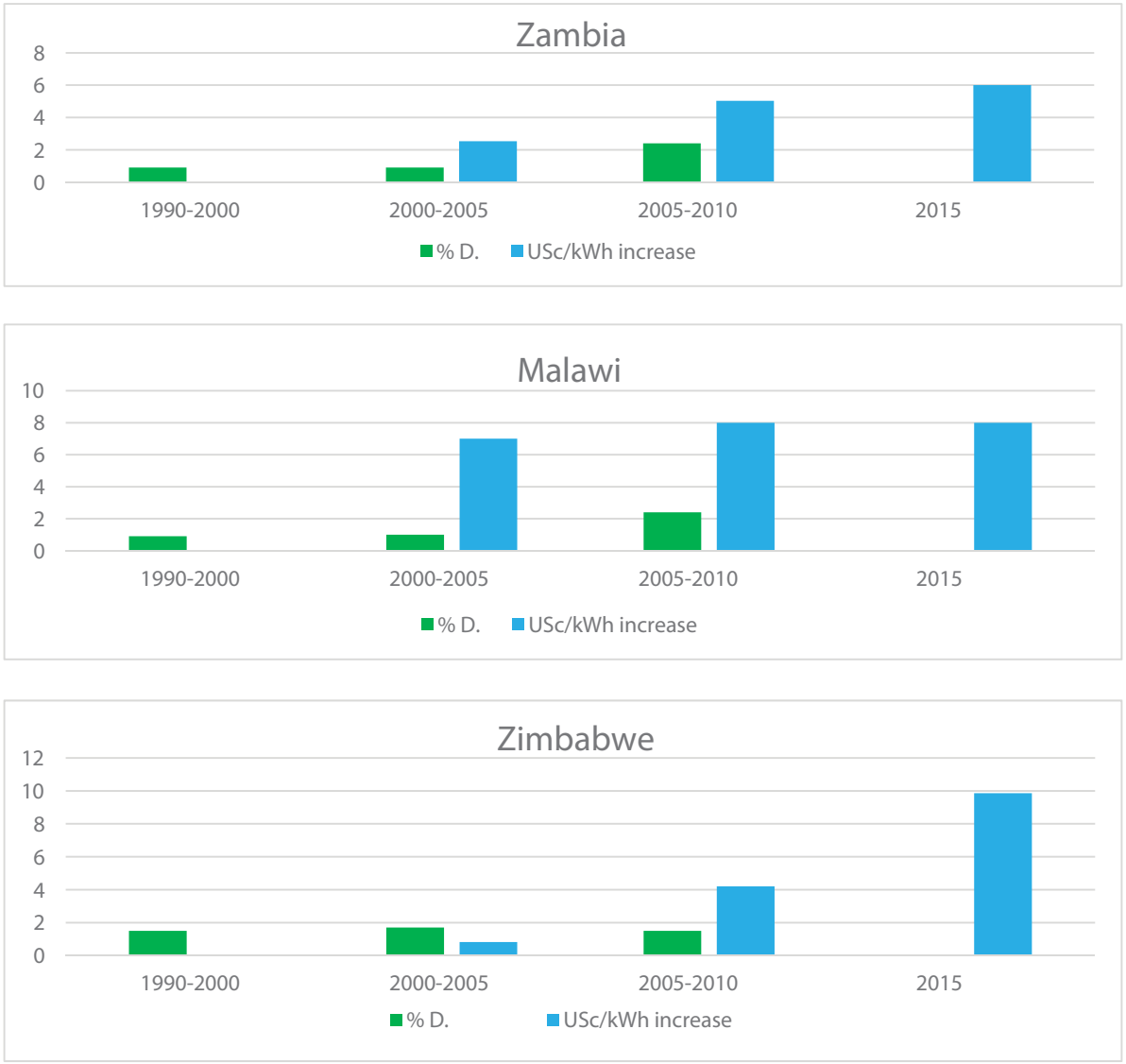
cost reflective tariffs; in itself a call by SADC which has largely remained unheeded since 2008 (SARDC 2010). However, in respect of the trends of applicable tariffs (Figures 2 and 3) and future transitioned cost-reflective tariffs, these being unaffordable for the majority of people in the southern African region, neither help reduce nor replace the present and future dependence on firewood and charcoal as a major source of energy.

The socio-economic importance of the woodfuel industry

An appreciation of the socio-economic status of fuelwood, observed from its contribution to GDP and employment, offers an opportunity for strategic thinking for the development of biofuels sector in the sub-region. A compilation of work done for a selected number of countries, summarised in Table 2, though not based on exact corresponding years, signifies national contributions to GDP of between 2.3–3.7% between 2007 and 2010, with that for southern Africa averaging 3.0% for 2008. The associated trade figures between 1991 and 2011 show a robust trade across countries to the tune of US$ 31.1 to US$ 650 million per year. Taking the example of Malawi, for which data between years were available, the increased trade of US$40 mil./yr to US$42 mil./yr from 2007 to 2011, the indication is that there is an increased trend in fuelwood trade in the sub-region. As a growing trade, IEA (2010) projects the trade for Africa to grow to US$ 12 billion per year by 2030, up from US$8 billion in 2007 (World Bank 2014).

The magnitude of the socio-economic importance of fuelwood in the sub-region is also best exemplified by examining its associated employment pull. The reported annual employment figures for the sub-region and Zambia in 2008 were 500,000 and in excess of 50,000, respectively while those for Malawi ranged from 92,800 to 200,000 between 2007 and 2009, representing a more than 200% growth in employment within the 3 years for the latter (Kambewa *et al.* 2007, Kalinda *et al*. 2008, MARGE 2009). Such an increased trend in employment is not uncommon to the sub-region and Africa as a whole and, put in perspective, it is quite understandable why the International Energy Agency (IEA) projects employment in Africa in the fuelwood industry to grow to 12 million people by 2030, up from over 7 million people engaged in 2007 (World Bank 2014). This increased importance entails

FIGURE 3 *Deforestation rates (%) and end user electricity tariff increases (US cents/kWh) (%D = Percentage Deforestation; US cents/kWh = United States cents per kiloWatt hour)*



increased status of the fuelwood sector to national and regional economies with the potential to outstrip some of the hitherto fiducially more important, priority sectors. Thus it is estimated for example that in Malawi, the unlicensed and therefore illegal charcoal industry operated by the 92,800 people recorded in 2007, had an estimated value of roughly about US$ 41.3 million, which was slightly less than the value of Malawi's tea industry (Kambewa *et al.* 2007). For Tanzania, the US$ 650 million per year contribution of the charcoal industry to its economy in 2009 is said to have been 5.8 times the combined value of coffee and tea production, apart from the generating incomes for several hundred thousand of households in both urban and rural areas (World Bank 2009). The studies done by the World Bank Energy Sector Management Assistance Programme (ESMAP) attest to this development by suggesting that promoting charcoal can create more jobs than any other forms of energy (Kakuzi 2003).

Challenges associated with the woodfuel industry in Southern African countries

The high dependence of predominantly poor urban to peri-urban households on charcoal and firewood as the main source of energy has been attributed to the fact that these sources of energy, as already noted (Hibajene and Kaweme 1993, Kambewa *et al.* 2007), are relatively cheaper when compared with electricity and petroleum-based fuels. The continued dependence and growth in urban demand for this form of energy in southern African countries continues to contribute to the loss of forests, largely through the unsustainable production and extraction of fuelwood. For instance, according to FAO, the annual deforestation rate in the SADC region amounted to 0.46% per year between 2005 and 2012, and since then the declining forest resources have further gone down by 0.6% per annum (SADC 2015), resulting in high biomass losses and carbon emissions. The extent of forest cover varies between countries, from insignificant (for

TABLE 2 *Fuelwood contribution to GDP, trade and employment in selected southern African countries with regional comparisons*

Country	Year	GDP %	Trade	Employment
Malawi	2007	3.0[a]	$ 40 mil./yr[a]	92,800[b]
	2008	3.0[b]		
	2009			200,000 [d,e]
	2010	3.5[d,e]		
	2011		$ 42 mil./yr[b]	
Zambia	2007	3.7[a]		
	2008		$ 3,000–9,000/yr/individual[c]	>50,000 [c]
Tanzania	2007	2.3[i]		
	2009		$ 650 mil./yr[f]	
Mozambique	2008		$ 200 mil./yr[i]	
Namibia	1991		$ 13.1 mil./yr[h]	
RSA	1991		$ 100 mil./yr[j]	
Southern Africa	2008	3.0[k]		500,000[g]
Africa	2007		$ 8 bil./yr[l]	>7 mi. [g]
	2030		$ 12 bil./yr projection[k]	12 mi. projection[k]

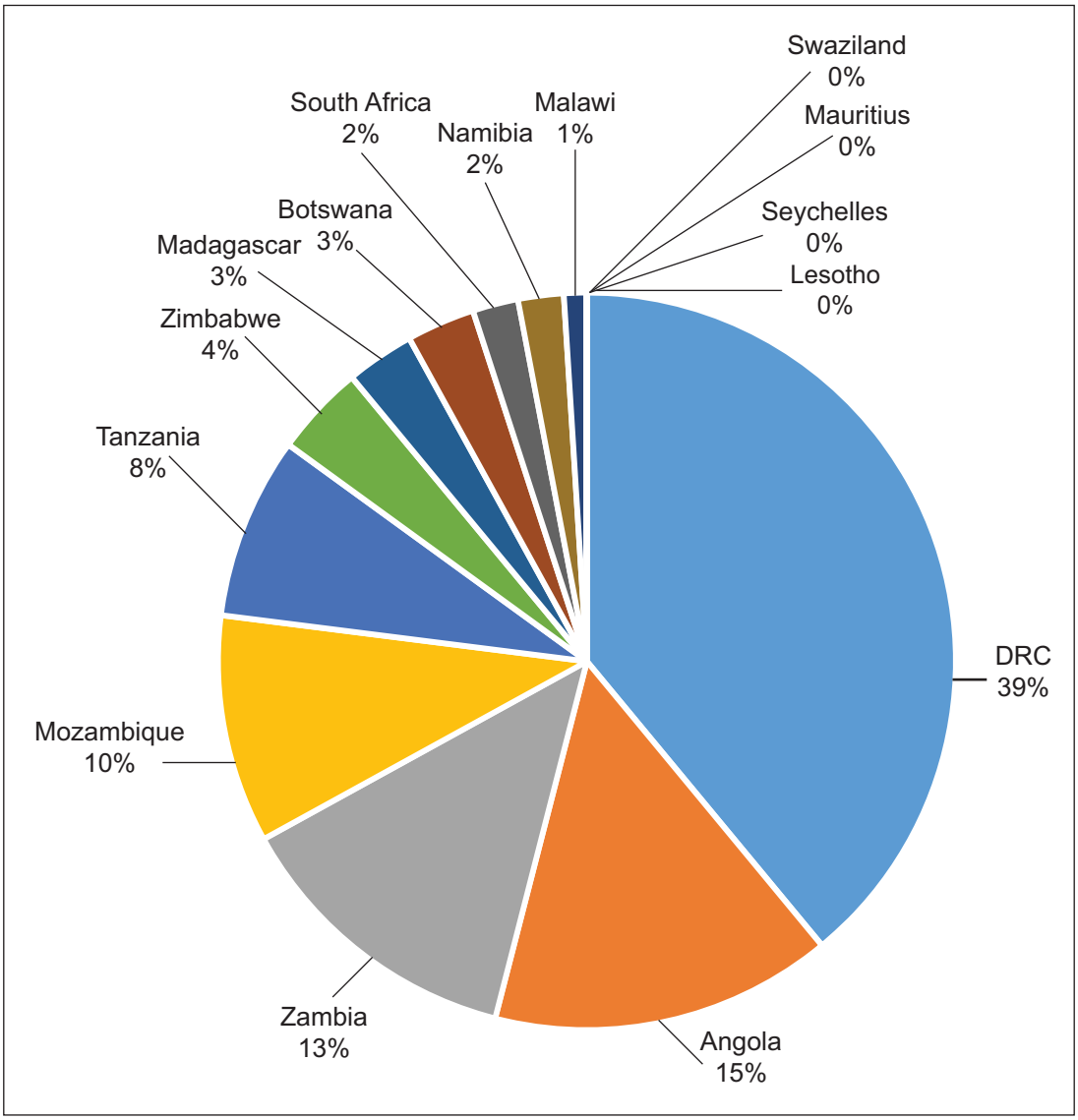
Sources: [a]Yaron *et al*. 2011, [b]Kambewa *et al.* 2007, [c]Kalinda *et al*. 2008, [d]Zulu 2010, [e]MARGE 2009, [f]World Bank 2009, [g]Von Maltitz 2013, [h]Hailwa 1999; [i] World Bank 2014, [j]DWAF 1997, [k]IEA 2010, [l]World Bank 2015.

example in Lesotho, Mauritius, Seychelles and Swaziland) to substantial (39% in DRC) levels (Figure 4) and although Yaron *et al.* (2010), Chittock (2010), Chidumayo and Gumbo (2013), Gondo (2013) and LTSI (2015) have attributed this due to impacts of varying drivers of deforestation, these changes have mainly been driven by agricultural expansion, fuelwood production and logging activities.

Most of these drivers of deforestation take place across a range of forest types rich in biodiversity, including the Miombo woodlands which represent one of the most extensive dryland forest vegetation types in Africa, stretching across seven countries in eastern, central and southern Africa from Zambia, Zimbabwe, Mozambique and Malawi to Angola and northwards into Tanzania and south-eastern DRC. Dominated by the legume family Caesalpiniaceae with the most prominent tree species being those of *Brachystegia* either alone or with *Julbernardia* and *Isoberlinia*, they occupy about 2.7 million square kilometres (White 1983, FAO 2000). Other related woodlands are the Kalahari Sands woodlands also dominated by the Ceasalpinioideae sub-family of the genera *Baikiea* and *Colophospermum* which cover much of northern Namibia, southern Angola and parts of Botswana, northern Zimbabwe and western Zambia (SADC 2010). The Mopane woodlands, dominated by *Colophospermum mopane* but also including a wide range of other species, are found in pockets across the Miombo and Kalahari Sands regions, including Mozambique, southern Malawi, northern Namibia, southern Angola and large parts of Zimbabwe and Botswana (FAO 2000). The greater Kalahari Sands woodlands region is also home to the drier Zambezian *Baikiaea* woodlands (including the species *Baikiaea plurijuga* or Zambezi teak) and the Kalahari *Acacia*/*Baikiaea* woodlands (Burgess *et al*. 2004).

In addition to these extensive woodland formations, the region is home to 'rich patch' forest vegetation, including riverine forests (or riparian woodlands) and at higher elevations, dry montane forests (Barrow 2014). An example is the Afromontane archipelago forests represented by forest patches in the Eastern Arc Mountains of Tanzania, the Mulanje Massif in Malawi and the Drakensberg in South Africa (SADC 2010). The region's coastline is a biologically rich and diverse mangrove ecoregion consisting of two large areas of mangroves in the deltas of the Zambezi in southern Mozambique and the Rufiji River in Tanzania. Smaller areas of mangroves are to be found along the coast in Angola, Madagascar, Mauritius, Seychelles and South Africa. The frequently unrelated plants comprising the mangrove formations in southern Africa involve nine different genera (*Xylocarpus* (Meliaceae), *Heritiera* (Sterculiaceae), *Sonneratia* (Sonneratiaceae), *Barringtonia* (Lecythidaceae), *Bruguiera*, *Ceriops* and *Rhizophora* (Rhizophoraceae), *Lumnitzera* (Combretaceae) and *Avicennia* (Verbenaceae), all of them contributing in one way or another to the mangrove belts and hugely important from an ecological perspective serving as nurseries and foraging grounds for numerous marine species for coastal protection and aquaculture (Palgrave 1983, Berjak *et al*.1977, Beentje and Bandeira 2007). However, the ecosystems exhibited by the above forest and vegetation types are under threat from woodfuel exploitation. For example, though fuelwood production and trade are regulated through a licensing system in Madagascar, whose objectives are for the conservation of the country's unique biodiversity (World Bank 2004), between 80% and 95% of the volume of charcoal is marketed illegally, largely due to difficulties in law enforcement (Minten *et al*. 2010). Such continued fuelwood production has resulted in land-use changes and further

FIGURE 4 *Forest cover distribution for SADC countries (FAO 2011)*



pushed production into the hinterland, further resulting in a range of ecosystems being used for charcoal production, with mangroves being the most prominent among them (Meyers *et al*. 2006).

The analysis on production and consumption reinforces and gives evidence of a defining future of continued dependence on charcoal as a major form of energy in southern Africa. Clearly, the high levels of consumption plus the high population growth and increased urbanisation can only lead to greater demand, implying increased production and consumption. A comparative analysis of the magnitude of increased annual consumption across Africa has revealed that southern Africa may well be the region on the continent with the most serious challenge in how to meet growing consumption levels from existing resources. The challenges facing the region in meeting the growing demand have been widely reviewed and acknowledged (Bond *et al*. 2010, Vinya *et al*. 2011, Zulu and Richardson 2013) to include weak, misguided, neglected, underdeveloped, disjointed, overly prohibitive, contradictory or non-existent policies and laws, combined with poor enforcement and regulatory capacity of the fuelwood industry.

The associated challenges facing the region have been analysed in terms of the extent to which fuelwood production may be linked to unsustainable charcoal and firewood production and the need to find suitable and sustainable alternatives, to migrate from use of biomass fuels to modern cleaner forms within a country's energy mix (e.g. petroleum-based alternatives (LPG and kerosene) and electricity). However, accessibility and affordability have been identified as the key reasons for people to continually depend on charcoal and firewood. Malawi, Zambia and Zimbabwe appear to show a continued upward surge in electricity tariffs which is consistent with increased rates of deforestation. This confirms that as long as electricity tariffs keep increasing beyond affordability for most people, continued and unsustainable production and consumption of fuelwood would be the order of the day into the foreseeable future. Compounding the issue of affordability for countries in the region, except for Namibia and Tanzania (reported to have already achieved cost

reflective tariffs), is the challenge that generally manifests itself in power deficits leading to load shedding, higher system losses and failure to attract investment. These have been observed as neither helping reduce nor replace the present and future dependence on firewood and charcoal as a major source of energy. In fact, taken together the combination of continuing growth in urban charcoal demand with rapid population growth, urbanization and increasing costs of alternative fuels including electricity affirms the dominance of charcoal in the energy mix of the region in the foreseeable future. These concerns have become more urgent than ever before as the charcoal industry is increasingly becoming more lucrative and in some cases operating under limited legal and policy frameworks (Gumbo *et al*. (2013). This study therefore draws the attention of SADC and countries in southern Africa to the fact that neither the unrelenting charcoal dilemma nor the electricity woes will disappear any time soon. It becomes imperative therefore as also noted by Zulu and Richardson (2013), that it is now time to proactively reform charcoal policies and laws to promote regulated, sustainable production and trading of charcoal.

To this extent, introducing major policy and institutional changes, integrating woodfuel issues in national economic and poverty reduction policies, which has hitherto been inadequate and tokenistic (Zulu and Richardson 2013), away from the status quo under current deforestation rates deserves serious attention in order to formalise and encourage investments in charcoal production. Without these interventions, it is difficult to see how the growing demand could be met, while at the same time contributing to and sustaining livelihoods, poverty reduction, national economies, employment, environmental sustainability, and mitigating and adapting to climate change.

Admittedly, wide diversity on the practical and policy front exists between countries, ranging from centralised and restrictive (e.g. in Tanzania and prior to enactment of new policies in Malawi and Zambia) to decentralised, innovative approaches (e.g., in Madagascar and RSA). The restrictions characterised by the former approaches have been found wanting, proved counterproductive and further pushed the illegal activities underground, leading to loss of government revenue, uncontrolled environmental degradation and increased levels of unsustainable production. The latter approaches have led to the adoption of innovative, decentralised sustainable charcoal production systems, where secure tenure rights are granted to individuals, households and the private sector through SFM afforestation/reforestation programmes. Similar approaches have been cited for some communities in Tanzania. In these approaches, an integrated policy framework is advocated involving many sectors including energy, forestry, agriculture, transport, and even health in order to have a comprehensive approach that takes care of the entire charcoal value chain.

Emerging opportunities in the woodfuel industry in southern African countries

The impetus for increased production, consumption and commercialisation of woodfuel is contributing to the growth of national economies, averaging about 3.0% for the region, through increased household incomes, tax revenues and employment along its value chain. These opportunities would be realised if there were effective institutional and policy frameworks to support the forestry sector in promoting the growth domestic product GDP) relative to other sectors of the economy in the face of climate change. For example, apart from Madagascar and South Africa (for commercial charcoal production), Namibia has valuable experiences worth sharing with the countries in the region on developing a sound charcoal policy framework. The Namibia framework exemplifies an innovative approach of how a by-product of cleared invader bush can be used to develop a thriving charcoal industry, which has grown significantly in the 2001–2010 period to become an important economic sector (Dieckmann and Muduva 2010). Charcoal exports have grown steadily in this period, with export volumes rising from 26,000 tonnes (t) in 2001 to 111,000 t in 2010, with a further 160,000 t exported in 2016 projected to increase to 200,000 t by 2020, i.e., by 25% compared to 2016.

Considering current market demand and the industry's ability to respond to such demand, Namibia is ranked among the top ten charcoal exporting countries worldwide and currently ranked as the fifth largest exporter of wood charcoal in the world, which also makes it the largest exporter of charcoal in the southern African region (Datham House 2018, TFT 2016). The policy created in terms of formal and international trade in wood energy is regarded as one of the most advanced in southern Africa with the industry, apart from satisfying local consumption, exporting charcoal to core markets in Germany, United Kingdom and South Africa (Kojwang 2000). The demand for the high quality charcoal from Namibia has increasingly led to the growth in the international market that now includes other core markets such as France, Greece and Poland (Figure 5), as the charcoal also continues to enter other new markets, such as countries of the Middle East and Australia (Datham House 2018, DASNAMIBIA 2018).

The steady growth of the charcoal industry in Namibia, alongside Madagascar and South Africa reflects the viability in southern Africa of taking some bold policy and legislative steps to register some success amidst challenges in the woodfuel industry. Some teething problems for coming up with a conducive and favourable policy environment must, however, be overcome. These include, for example, the industry being largely a "hidden" sector, receiving little policy attention, its economic role almost always overlooked and being systematically underestimated, among others, and yet it provides energy for more than 80% of a country's population (NL Agency 2010). As woodfuels often escape official statistics, the sector's contribution to a national economy is often marginal (2–4%), resulting in little forest governance attention and meagre budgetary allocations and attendant weak governance and institutional arrangements. Ultimately, such institutional weaknesses, coupled with unclear policy and legal frameworks, are regarded as major causes of unregulated or even illegal charcoal businesses and corruption (NL Agency 2010). Just as land tenure is a key issue that must be addressed, for it is when land-use rights are clear that resource management can be undertaken effectively (FAO 2010),

FIGURE 5 *Relative export volumes (t) of Namibian wood charcoal in 2016 (in descending order, 93,600t-RSA; 10,300t-UK; 6,100t-Greece; 5,400t-Poland; 4,800t-Germany; 3,300t-France; 2,500t-Cyprus; 2,200t-Belgium; 1,900 t-Portugal)*

Source: Chatham House (2018) 'resourcetrade.earth', http://resource trade.earth/

so too the above policy and legislative weaknesses for a successful woodfuel industry.

Though regarded as a rather young woodfuel industry, having developed in the last 30 years, bold policy and legislative decisions made and implemented in Namibia, as reviewed below (TFT 2016, DASNAMIBIA 2018), to confront environmental and economic challenges are worth emulating. These have made the country to be internationally recognised with a well-regulated and organised industry. While recognising that environmental and economic challenges differ among countries in southern Africa, development of and progress in the woodfuel industry lies in identifying and aligning particular policy frameworks for given challenges. For Namibia, the policy framework allows for charcoal production from encroacher species which include blackthorn Acacia *(Acacia mellifera / Senegalia mellifera)*, red-rind Acacia *(Acacia reficiens / Vachellia reficiens)*, and other Acacia species, mainly from commercial farms. These excessively spreading thorny and impenetrable bushes and shrubs, which have drastically contributed to the decline of palatable grass for livestock, reduced seepage of rain into groundwater, reduced biodiversity and hampered agricultural productivity thereby presenting immense challenges, have provided significant opportunities for charcoal production. Bush control through selective harvesting for charcoal production, generating a demand for biomass input of approximately 600,000 tonnes per annum, while used for rehabilitating and restoring ecosystems, is of enormous economic value.

The enabling policy framework that allows for bush harvesting for charcoal production is regulated by a number of Namibian forestry and environmental policies. Since 1990, the Namibian Government has adopted a number of these policies to promote sustainable development and integrate principles thereof into a number of national policies, supported by various key international, regional and national legal instruments and policies. These include the Environmental Assessment Policy for Sustainable Development and Environmental Conservation (1995); Environmental Management Act (2007); Atmospheric Pollution Prevention Ordinance No. 11 of 1976; Forest Act, 2001, as amended by Act No. 13 of 2005. All these stress the need for sustainable renewable resource management, community involvement, equitable benefit sharing and access to environmental resources, and protection of biodiversity, among others. These provisions have made charcoal a strategic industry that, in agreement with the country's Fifth National Development Plan (NDP5), is specifically focused on economic development. Since the barriers for entry into the charcoal industry are relatively low, there is also scope for the creation of small and medium enterprises (SMEs).

The highly regulated charcoal industry, under the Environmental Management Act, requires every producer to have an Environmental Clearance Certificate obliging the producer to conduct an environmental impact assessment (EIA) prior to commencing charcoal production because such production includes the clearance of forest areas, deforestation and afforestation, and may fall under Atmospheric Pollution Prevention Ordinance No. 11 of 1976. The decision to require an EIA or not rests with the Directorate of Environmental Affairs in the Ministry of Environment and Tourism (MET).

This gives an example that streamlining and harmonization of policies is necessary as a prerequisite for an enabling environment for sustainable woodfuel and charcoal provision (NL Agency 2010)

Under the provisions of the Forestry Act various permits, issued by the Department of Forestry, are a requirement for commencing charcoal production and at the various stages covering the entire value chain. These include the Harvesting Permit, which is only issued after an inspection is done on the farm to investigate whether there are the right and sufficient resources available to grant given quantities of production as applied for by the applicant; the Marketing Permit, indicating the marketplaces and the origin of the charcoal to be marketed, the Transport Commercial Permit, for the sale of charcoal; the Export Commercial Permit to enable exportation of charcoal as a forest product to other countries, as well as the Export for Own Use Permit. The Department of Forestry is obliged to conduct regular inspections on charcoal-producing commercial farms to avoid deforestation.

The above set of provisions show a regulated industry that has a well-organised charcoal value chain with all processes firmly regulated for a network of stakeholders, including producers, harvesters and burners, processors and traders, agents and distributors. Currently, there are around 604 registered charcoal producers in the country, most of them commercial or emerging farmers, committed to the strict international regulations of the Forest Stewardship Council (FSC), which ultimately secures the best price for their product. The charcoal is then sold to processors (currently 13) and traders, who purchase charcoal in bulk, process it and distribute it to different clients and markets. The product is refined according to the technical parameters agreed with their international clients such as carbon fixation, ash content, volatile matter and moisture content. The international clients, as agents and distributors, are importers in buyer countries, and they play a vital role in marketing Namibian charcoal. This defines the vibrancy of the market as the charcoal is promoted and enters the consumer market under more than 15 different brand names, e.g., Jumbo Charcoal, Savannah Charcoal, Carbo Charcoal, among others. The rest enters the market through South African trademarks.

Groups formed in the country to support the network of stakeholders on different levels in the charcoal industry include the Namibia Charcoal Association (NCA), the Namibia Agricultural Union (NAU) and the Namibia Biomass Industry Group (N-BiG). The NCA, a non-profit voluntary membership association, supports the initiatives of producers, labourers, processors, and all other stakeholders and creates an environment conducive to good relationship amongst them; conveys the coordinated views of the industry and co-operates with the authorities to negotiate solutions and to advocate for necessary legislation that benefits the industry; engages in creating uniform standards to the benefit of all stakeholders and customers; interacts with all national and international stakeholders to the benefit of the industry; develops and facilitates trainings for charcoal workers, producers and processors. It also hosts the annual Charcoal Conference and Expo with a broad range of participants from Namibia and abroad. It is closely affiliated with the Namibia Agricultural Union (NAU) and coordinates its efforts with other relevant industry bodies, such as the Namibia Biomass Industry Group (N-BiG) (DASNAMIBIA 2018).

By exporting charcoal to South Africa, a neighbouring and fellow SADC member country, Namibia demonstrates the existence of and potential for cross-border trade in charcoal between countries in southern Africa. Already, the commercial charcoal produced by companies in South Africa formally finds its way in supermarkets in the region, though largely meant for the middle-income clientele. The region also appears to have well established informal and formal cross-border trade and routes across countries such as Malawi, Mozambique, Zambia, Zimbabwe and Tanzania (Minde and Nakhumwa 1998, Gumbo *et al*. 2013).

Since this regional informal trade has been growing for decades due to its increasing high-demand across countries in southern Africa, one important lesson for the region to learn is that charcoal has increasingly become such an important socio-economic commodity that it can no longer remain in the informal sector. Sooner rather than later, existing trade agreements between countries, mainly under the coordination of SADC and Common Market for Eastern and Southern Africa (COMESA), will have to become part of the normal formal trade between countries. Otherwise, the absence of the shift from informal to formal trade in the charcoal sector will always frustrate and retard regional efforts for coordinated SFM for charcoal production. This will in turn compromise efforts in reducing deforestation and forest degradation, curbing environmental degradation and impacts of climate change. The enabling framework that should drive the commitment towards such a paradigm shift would precisely draw on the positive experiences from Madagascar, Namibia, South Africa and other countries in SSA such as Sudan and Rwanda, provided there is willingness between countries under the guidance of SADC and COMESA to learn from each other.

The sub-region should also take full advantage of information from research work done on miombo woodlands in the region (Girard 2002, Malimbwi *et al.* 2005), depicting it as providing a conducive environment for implementing SFM for charcoal production. This is because, following disturbance caused by firewood and charcoal production, the reduced production pressure can later make such areas progressively revert to woodlands (Malimbwi *et al*. 2005) and in some cases, lead to higher productive miombo woodland ecosystems once disturbances have ceased (Geldenhuys 2005, Malambo and Syampungani 2008, Syampungani 2008).

This research information must inform policy reforms as it brings to bear opportunities for developing SFM based on sound rotational harvesting regimes for sustainable charcoal production. This research-based information and other silvicultural management prescriptions for sustainable woodfuel production have, however, largely been ignored and therefore not mainstreamed in any governing policies in the sub-region. This points to the need for countries in the region to urgently develop programmes to resolve the ever-growing science-policy divide in order to make progress towards a viable and sustainable fuelwood production. In this regard, countries in

the region have a lot to learn from each other to harness the positive experiences and not 're-invent the wheel' for a viable fuelwood industry.

CONCLUSION AND RECOMMENDATIONS

The experiences and practices gathered from southern African countries show that the woodfuel industry has the potential to spur socio-economic development relative to other sectors of GDP. This industry is also significantly relied on by most rural and peri-urban dwellers as a major source of energy for household and income. However, the woodfuel industry is also contributing to alarming rates of deforestation in southern Africa resulting in loss of biodiversity, inadequate provision of ecosystem services and environmental degradation among others. In order to address both the opportunities and challenges associated with the woodfuel industry in the SADC region, the following recommendations are proposed for consideration by respective member states:

1. faced with declining forest resources, competition from the mining sector and between food, fibre and energy needs, the growing energy demands and associated GHG emissions, the region must promote the development of harmonised policies and regulatory frameworks for formal trade and investments in renewable energy, energy conservation and energy efficiency critical in reversing the trends in forest loss. This entails, for example, promoting research and development in charcoal and firewood production and consumption, strengthening regional integration in planning and development of renewable energy, including communication and information sharing on renewable energy technologies and enhanced energy infrastructure development;
2. the region needs to revisit the charcoal production value chain at policy and practice levels in an integrated manner with the explicit purpose to incorporate an inter-sectoral approach and avoid sectors that directly or indirectly influence SFM and charcoal production working in isolation to one another. Given the sectors involved in the whole value chain, there is need for integrated formulation of policies, which should also provide for the effective regulation of the fuel sector through the continuous monitoring of activities of the charcoal industry in relation to prices, trends, and volumes of production and consumption levels;
3. existing trade agreements between countries mainly under the coordination of SADC and COMESA must incorporate charcoal production and trade, with charcoal becoming part of the normal, formal trade between countries in order to move away from the largely informal trade which retards regional efforts for coordinated SFM and compromises efforts in reducing deforestation and forest degradation, curbing environmental degradation and reducing impacts of climate change. The enabling framework that should drive the commitment towards such a paradigm shift should draw on the positive experiences from Madagascar, Namibia, South Africa and other countries in SSA such as Rwanda, provided there is willingness between countries under the guidance of SADC and COMESA to learn from one another. These would essentially lead the region to minimise forest losses, develop and implement sustainable methods of extraction and utilization of woodfuel by improving efficiency technologies, encourage use of alternative energy sources and use of plantation species in charcoal production;
4. participatory or community forestry approaches, well-established in the region, must be used to effectively track changes in the levels of fuelwood production and consumption. These approaches still remain strategically important for the implementation of SFM of woodfuel in the region. The adoption of these approaches will also help the region move away from the centralised control and management of forest resources. To this extent, the new approaches and relevant policies must be monitored, and countries must share experiences and learn from each other; and
5. for marginal and/or degraded public forest areas, involvement of the private sector and local communities as a workable option, with potential to ameliorate land that would otherwise continue to remain idle, unproductive and continually degraded.

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APPENDICES

APPENDIX I CHANGES IN DEFORESTATION AND ELECTRICITY TARIFFS IN SELECTED COUNTRIES.

Country	Annual rates of change					
	1990–2000	2000–2005		2005–2012		2015
	Deforestation (% change)	Deforestation (% change)	Av. end user electricity tariff increase (USc/kWh)	Deforestation (% change)	Av. end user electricity tariff increase (USc/kWh)	End user electric. tariff increase (USc/kWh)
Angola	-0.2	-0.2	9.19		9.95	3.10
Botswana				-0.9		-
Madagascar	-0.8	-0.5		-0.4	-	-
Malawi	-0.9	-0.9	7.00	-2.4	8.00	8.00
Mauritius				-0.6		-
Mozambique	-0.3	-0.3	6.63	-0.2	7.14	8.15
Namibia			8.73	-0.9	8.73	15.00
South Africa			4.05	-0.1	5.48	6.22
Swaziland			6.80	1.2	10.09	11.72
Tanzania	-1.0	-1.1	9.29	-0.2	10.44	16.04
Zambia	-0.9	-1.0	2.53	-2.4	5.03	6.00
Zimbabwe	-1.5	-1.7	0.82	-1.5	4.20	9.86

Source: Adapted from FAO (2007); Magombo *et al.* (2010); AECOMID (2011); Kaunda (2014); RERA (2015); SADC (2015); Sikwanda (2016).

Food-fuel-fibre nexus: towards the framing of sustainable biofuel strategies for climate change mitigation in the Congo Basin

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SUMMARY

Biofuel is increasingly gaining attention as a more environmentally friendly fuel and a substitute for fossil fuel because of its climate change mitigation potential. However, a robust policy and institutional framework is required to guarantee its sustainability. This paper examines the biofuel crop policy domain in Cameroon, the Democratic Republic of Congo and the Republic of Congo. Despite the ongoing large scale expansion of biofuel crop plantations in the Congo Basin, national policy strategies that direct the production and consumption of biofuels are lacking. The expansion of biofuel plantations in the Congo Basin poses a threat at many levels with negative and unintended consequences. Food security, forest cover and biodiversity loss, threatened indigenous and local communities' customary land rights are examples of likely undesirable outcomes from the emerging biofuel sector. Notwithstanding, there are opportunities to make biofuel respond to both climate change mitigation and social and economic development objectives in the region.

Keywords: biofuel crops, environmental degradation, mitigation, Congo basin, sustainability

Liens entre aliment-carburant-fibre: vers la formulation des stratégies de de production durable des biocarburants pour l'atténuation des changements climatiques dans le bassin du Congo

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Les biocarburants attirent de plus en plus l'attention en tant que combustibles plus respectueux de l'environnement et substituts des combustibles fossiles en raison de leur potentiel d'atténuation des changements climatiques. Cependant, un cadre politique et institutionnel solide est nécessaire pour garantir sa durabilité. Cet article examine le domaine de la politique de production des cultures à biocarburants au Cameroun, en République Démocratique du Congo et en République du Congo. En dépit de l'expansion à grande échelle des plantations a base des espèces a biocarburants en cours dans le bassin du Congo, les stratégies politiques nationales orientant la production et la consommation de biocarburants font défaut. L'expansion des cultures à base de biocarburants dans le bassin du Congo constitue toutefois une menace à plusieurs niveaux, avec des conséquences négatives et imprévues. Parmi les conséquences indésirables à prévoir face à l'émergence du secteur des biocarburants, quelques exemples à mentionner sont l'atteinte à la sécurité alimentaire, la perte du couvert forestier et de la biodiversité, les menaces sur les droits fonciers coutumiers des communautés autochtones et locales. Néanmoins, il y a des opportunités de faire en sorte que la production des biocarburants réponde aux doubles objectifs d'atténuation des changements climatiques et de développement social et économique de la région.

El vínculo entre alimentos, combustibles y fibras con miras a la elaboración de estrategias sobre biocombustibles sostenibles para la mitigación del cambio climático en la cuenca del Congo

E. CHIA, K. ENONGENE, K. FOBISSIE y M. LARWANOU

El biocombustible está ganando cada vez más atención como un combustible más respetuoso con el medio ambiente y un sustituto de los combustibles fósiles, debido a su potencial de mitigación del cambio climático. Sin embargo, se necesita un marco político e institucional riguroso para garantizar su sostenibilidad. Este artículo examina el ámbito de la política de cultivos para biocombustibles en Camerún, la República Democrática del Congo y la República del Congo. A pesar de la continua expansión a gran escala de las plantaciones de cultivos para biocombustibles en la Cuenca del Congo, se carece de estrategias políticas nacionales que guíen la producción y el consumo de biocombustibles.

La expansión de las plantaciones para biocombustibles en la Cuenca del Congo representa una amenaza a muchos niveles, con consecuencias negativas e imprevistas. La seguridad alimentaria, la pérdida de la cubierta forestal y la biodiversidad, o las amenazas a los derechos consuetudinarios sobre la tierra de las comunidades indígenas y locales son ejemplos de consecuencias probables no deseables del sector emergente de los biocombustibles. No obstante, existen oportunidades para hacer que los biocombustibles respondan tanto a los objetivos de mitigación del cambio climático como a los de desarrollo social y económico en la región.

INTRODUCTION

The increase in demand for fossil fuels, their increasing prices coupled with climate change constraints have culminated in attention being focussed towards biofuels in recent years. The burgeoning interest in biofuels as a substitute for fossil fuels has resulted in the unprecedented expansion of biofuel crop plantations in biodiversity hot spots across the tropics. The establishment of large-scale plantations for the cultivation of biofuel crops often occurs at the expense of the natural forest. According to Eisner *et al*. (2016), global loss in biodiversity is primarily caused by the expansion of agriculture. The links between the establishment of palm plantations and deforestation is evident in Malaysia and Indonesia (Clay 2004). The establishment of palm plantations in Malaysia and Indonesia from 1990 to 2005 resulted in the destruction of 1.1 million and 1.7 million hectares of forest respectively. In the course of this 15-year period, 50 to 60% of the expansion of palm plantations led to the destruction of the natural forest (Koh and Wilcove 2008); of which most of the destruction was illegal.

Biofuel is advocated as an environmentally friendly fuel with the potentials to reduce greenhouse gas emissions that drive global climate change. While this novel environmentally friendly fuel has the potential of mitigating global climate change, concerns have been raised over its potential impact on the production of other agricultural crops and consequences on food security (Ji and Long 2016). Furthermore, in some countries in Africa e.g. Ghana and Zambia, biofuel production has resulted in social and environmental impacts on livelihoods and biodiversity (German *et al*. 2011, Schoneveld *et al.* 2011).

The Congo Basin forest constitutes the second largest tropical forest in the world after the Amazon spanning six countries, namely; Cameroon, Central Africa Republic, Democratic Republic of Congo (DRC), Equatorial Guinea, Gabon and Republic of Congo (RoC). The forests contain diverse flora and fauna species possessing the world's largest number of plants species per unit area and a variety of animal species (de Wasseige *et al*. 2012). More importantly, the Congo Basin forests serve as home to over 30 million people and support the livelihood of about 75 million people from 150 ethnic groups in the Central African sub region who rely on the forests for food, health and nutritional requirements (Megevand *et al*. 2013).

The forests in the Congo Basin also plays an important role in mitigating global climate change through their capacity to sequester two-thirds of the carbon stored in live vegetation in Africa (COMIFAC 2013). However, planned and ongoing expansion of palm plantations in the Congo Basin is occurring in forested zones and this expansion constitutes a current and future driver of forest clearance in the Congo Basin (Enongene and Fobissie 2016, Tegegne *et al.* 2016). Thus, while the expansion of palm plantations presents a window of opportunity for economic growth to the Congo Basin countries, it poses a threat to the biodiversity of the region. Furthermore, the weak land tenure system that exists in the Congo basin countries renders forest dependent communities vulnerable. Forest communities rely on customary rights over their forest and in most cases lack a formal land title. Consequently, the expansion of biofuel crop plantations in the Congo Basin is likely to culminate in the expropriation of forestland of indigenous and forest dependent communities.

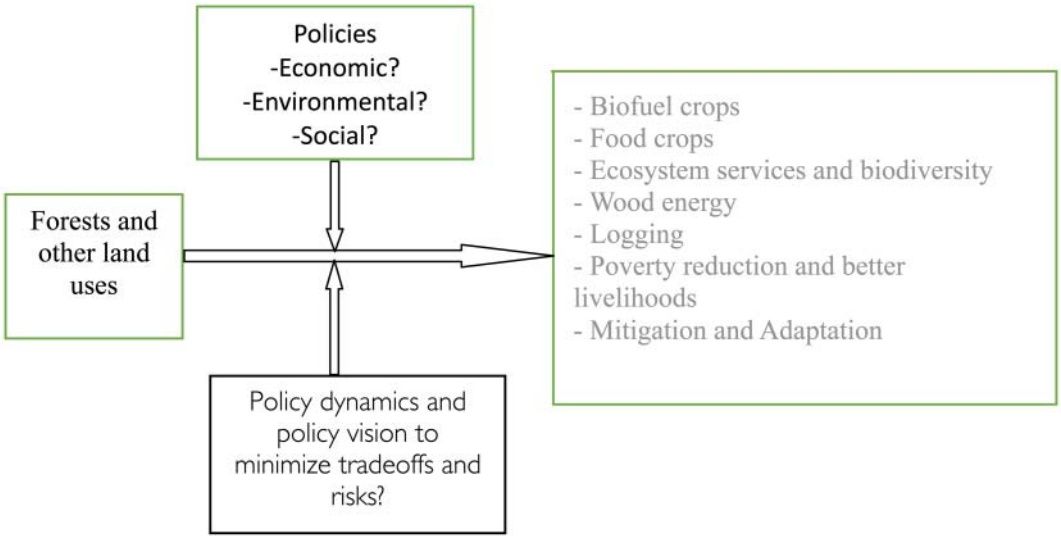
The Congo Basin countries have made commitments towards the mitigation of global climate change, where forest and other related ecosystems are considered as part of the solution. These countries, with the exception of Equatorial Guinea are participating in the avoided deforestation, avoided forest degradation, sustainable forest management, and enhancement of forest carbon stocks and conservation of forest carbon stocks (REDD+) initiative, under the Forest Carbon Partnership Facility (FCPF 2015). Balancing the conservation of forest as part of the REDD+ objectives and the implementation of developmental projects including, but not limited to, biofuel crop plantations will be complex and challenging (Mboringong and Enongene 2015). Hence, it is important to formulate and implement sustainable strategies pertaining to biofuel production and consumption in order to mitigate the likely undesirable outcomes in the Congo Basin countries.

So far, a number of studies (Enongene and Fobissie 2016, Tegegne *et al*. 2016, Megevand *et al*. 2013, Rainforest Foundation 2013 and Duveiller *et al*. 2008) have identified the expansion of agro-industrial plantations as one of the drivers of forest cover loss in the Congo Basin. As the debate on the importance and risks of biofuels intensifies at the global level, reflections at national and regional levels are important. Thus the need for policy inputs to fuel strategy development debates at national and regional levels. It is within this framework that this study sought to examine the extent to which biofuel crop plantations are expanding, the social and environmental impacts of biofuel crop plantations and sustainable biofuel production and consumption features in the Congo Basin region.

FOOD-FUEL-FIBRE (3FS) RELATIONSHIPS IN THE CONTEXT OF CLIMATE CHANGE

Forests and other related land uses play an important role in the mitigation of global climate change through the sequestration and/or conservation of carbon stocks. Forests also serve

FIGURE 1 *Relationships between forests and other land uses and ecosystem goods and services including food-fuel-fibre (3fs)*



as a source of food and fibre (non-timber and timber forest products) to both rural and urban populations. Fuel is needed in the preparation of food and a significant proportion of the population in developing countries obtain fuelwood from forests and related ecosystems for heating. As the human population grows, more food is needed to feed the growing population and agriculture, especially slash and burn in developing countries, drives the clearance of forest cover which causes climate change and reduces the capacity of forests to provide fuel, food and fibre.

Global environmental concerns over the emission of greenhouse gases emanating from the burning of fossil fuels has resulted in an increased importance and recognition of the potential role of biofuels in climate change mitigation (Koh and Ghazoul 2008). There has been a recent expansion of plantations for the cultivation of biofuel crops to meet the increasing global biofuel demand. Climate change mitigation through the replacement of fossil fuels with biofuels have the potential to limit the capacity of forests and other land uses to provide ecosystem goods and services relevant to the 3fs. The balance between the 3fs and climate change mitigation will depend on the strength of the economic, environmental, social policies and strategies that will be put in place at national and regional levels. Using biofuels as a case study, strategies need to ensure that environmental, social and economic values are protected during design and implementation. The relationship between forests and related land uses and ecosystem goods and services including the 3fs and the implications of economic and environmental policies in enhancing or impeding this relationship is shown in Figure 1.

METHODOLOGY

The study employed data from primary and secondary sources through a two-step data collection approach. In the first step, a thorough literature review of scientific, grey literature and biofuel related sectoral strategy documents (agriculture, energy, rural development, development strategy papers etc.) was conducted in relation to the research objectives. This also permitted the identification of actors involved in biofuel related interventions in each country. Primary data were collected through interviews using semi-structured questionnaires in the case study countries. Twenty-six (26) respondents representing government (8), NGOs (15), private sectors (2) and research (1) were interviewed. A Likert scale was used to rate the responses of actors, ranging from 1 - meaning strongly agree - to 5 – don't know. Simple descriptive statistics were used to evaluate the position of the actors (expressed in percentages) in relation to the different stances linking biofuels to forest cover and biodiversity, food security, land use conflicts, environmental policy awareness and implementation. Furthermore, the level of satisfaction of actors in relation to the implementation of ongoing biofuel related interventions were also evaluated on a scale of 1-5, with 1 representing very satisfied and 5 meaning don't know. Analyzing the stances of different actors is important because it gives insights into the direction in which the biofuel strategy development process is likely to take. The opinion of experts at the national level is appropriate in providing adequate national policy responses to activities that drives forest cover change (Tegegne *et al*. 2016).

RESULTS AND DISCUSSION

State of biofuel expansion in the Congo Basin

The predominant biofuel crop in the Congo Basin is palm from which palm oil is obtained. According to the Rainforest Foundation (2013), confirmed and potential projects for the exploitation of palm oil in the Congo Basin (Table 1) is over two-third (115 million hectares) of the total surface area of the Congo Basin forest.

TABLE 1 *Information of known projects on the expansion of palm oil production in the Congo Basin*

Country	Name of Company	Information
Cameroon	PALM CO	100,000 ha of plantation envisaged
	CDC	6000 ha of plantation established in 2009
	SMART HOLDINGS	25000 ha of plantation envisaged
	CARGILL	$390 million contract signed for an area of 50000 ha
	GOOD HOPE	Envisage to obtain 6000 ha
	BIOPALM ENERGY	Obtained 53000 ha but envisaged to obtain at least 200,000 ha
	HERAKLES FARM	Concession of 73086 ha
	SIME DERBY	600,000 ha is envisaged
Gabon	OLAM	Ongoing 100,000 ha of plantation
	SIAT	Possess 6000 ha in view of expansion of its exploitation
Republic of Congo	BIOCONGO GLOBAL TRADING	Concession of 60000 ha of $150 million
	FRI-EL GREEN	40000 ha accorded for the production of biofuel
	ENI	Memorandum of understanding signed for 70000 ha
	ATAMA PLANTATION	Concession of 470000 ha
	AURANTIA	In 2007, the Spanish company Aurantia had the intention of establishing four plantations and a transformation factory for palm oil on millions of hectares geared at biofuel production
Central Africa Republic	PALMEX	Concession of 8701 ha
Democratic Republic of Congo	ZTE	Surface area of 100000 ha

Source: Rainforest Foundation, 2013.

The global demand for palm oil has significantly increased over the past few years and has gained a significant proportion of the market as compared to other vegetable oils. This expansion is due to increase in consumption in the countries (China, India and other emerging Asian countries) where palm oil is used extensively as a cooking oil. Presently, global demand surpasses supply, a trend that is likely to continue into the foreseeable future making it particularly attractive for investors. Furthermore, increasing regulations, preventing the clearing of forests, land scarcity, and the hopes raised by the emerging REDD+ mitigation initiative in the major producing countries of Malaysia and Indonesia is encouraging Asian companies to diversify their production areas targeting the Congo Basin (Hoyle and Levang 2012). At the regional level, the Congo Basin is targeted for the following reasons: good physical conditions; availability of cheap land; increasing importance of the agriculture sector to the economic development of the countries of the region; closeness of the region to the EU and North America market where palm oil is used principally for manufacturing goods (Hoyle and Levang 2012, Megevand *et al*. 2013).

Policy and institutional arrangement

In the countries of the Congo Basin, biofuel production and commercialization appear to be emerging issues. There are no policy objectives or national strategy on biofuel production and consumption. Information from documents and expert interviews revealed that countries are still at the level of making national reflections on developing policies related to biofuel production and consumption. There is no clear policy vision on the scale of biofuel production, domestic consumption and export ratio, or process of transformation. Furthermore, it is still not clear whether the crop expansion is for domestic consumption as cooking oil, or for biofuel production. There is limited information available on the investments related to biofuel crops and biofuel production in general. Such missing policy inputs are relevant for developing viable strategies.

> *Agreements between the government and multinational companies on the economic, social and environmental aspects of biofuel crop production have not been disclose to the public (A respondent from the Republic of Congo)*

In the different countries visited, experts had the feeling that they were not being involved in the preliminary reflections on biofuel policy development. Some experts argue that biofuel is a multi-sectoral and multi-actor issue that requires a broad participation of all relevant actors e.g. actors from relevant ministries, international multilateral and bilateral organisations, international and local NGOs.

The three countries visited have different ministries leading the biofuel sub-sector strategy development process, depending on the general government policy frameworks, which at times appear ambiguous. For example in the DRC the process is steered by the ministry of Hydrocarbons, in the

Republic of Congo by the ministry of Agriculture and Livestock, and in Cameroon by the ministry of Energy and Water. Most of the experts interviewed agreed that countries of the region have inadequate technical and financial capacity to elaborate and implement a comprehensive biofuel strategy. It was stressed that technical support is imperative for the countries in the region. Discussions, reflections and actions which are still at an early stage should consider taking into account policy components that fully capture the environmental, social, economic and institutional aspects of biofuel production and consumption.

Biofuel-agriculture and food security

In the countries visited, about 62% of the experts agreed that the agriculture sector of the countries in the Congo Basin has the potential to provide for biofuel production and food. The opinion of the experts corresponds with the findings of Ajanovic (2011), which revealed that biofuel production had no significant impact on feedstock prices, and they arrived at the conclusion that biofuel can possibly co-exist with food production. However, at the moment there are no strategies that provide guidelines to ensure the balance between biofuel crop production and food security in the Congo Basin. Some experts also noted that there is need for gradual adjustments to be made, though with care. For example, placing too much limitation on biofuel crop production could constitute a solution. Ironically, the biofuel sector has great potential in terms of employment opportunities as biofuel (ethanol and biodiesel) production requires more workers than those employed in the production of gasoline and diesel (Silalertruksa *et al*. 2012). In Thailand for instance, Silalertruksa *et al*. (2012) estimated that the nation's biofuel sector will generate an employment of around 238,700–382,400 person-years by 2020 while Malik *et al*. (2014) concluded that the introduction of sugarcane-based biofuel industry in Australia would bring significant employment to the country. Hence, limiting biofuel crop production as a solution to ensuring food security would likely have serious equity concerns since it might limit employment opportunities, wages and income of farmers in rural poor areas of the Congo Basin and this will conflict the employment objective of the green economy programme of the Economic Community of Central Africa States (ECCAS) of which the Congo Basin countries are members (Enongene and Fobissie 2016).

There are serious concerns that biofuel crop production will threaten food security. As opined by Ji & Long (2016), biofuels have a negative impact on food security and their claim is supported by studies conducted by Chakravorty *et al*. (2016) which showed that world food prices will increase by about 32% by 2020 partly due to biofuel.

Biofuel, land security and conflict

All interviewed experts agreed that biofuel crop production will create land use conflicts between companies and local communities and indigenous peoples, who depend on customary land rights. The cultivation of biofuel crops is often carried out by foreign companies who normally require a large expanse of land. Experience in the different countries indicates that land tenure arrangements are unclear, and the land allocation processes are frequently not transparent. This creates opportunities for companies to manipulate and marginalised local communities. The procedures for obtaining a land title is complex, financially entailing and further exacerbated by poor governance and corruption that plagues Congo Basin countries. Indigenous and local communities are unlikely to be financially viable to engage in land title procedures and are left with no option than to hold on to their customary rights over land. Under such a scenario, the state can easily attribute ancestral land as concessions to palm oil companies without seeking free, prior and informed consent (FPIC) of the concerned indigenous and/or local communities.

In most cases, land allocated for palm plantations are customary lands over which communities had in the past enjoyed their customary land rights. The deprivation of communities of their customary rights as a result of the attribution of their customary and ancestral land as concessions for palm plantation culminates in conflict between the concerned communities and the palm oil producers. Where the law of the state demands for Free, Prior, Informed Consent (FPIC) of communities prior to use of their customary lands, this law is often violated by the government and palm oil companies (Rainforest Foundation 2013). In some cases where the FPIC of the concerned community is sought, false information is made available to the community accompanied by fake promises in order to obtain their consent (Friends of the Earth 2008). Experience from Indonesia revealed that the rapid expansion of palm plantations resulted in different land conflicts characterized by manifestations, arrest of some members of the population, displacement of communities, torture and death (Rainforest Foundation 2013). Indigenous and local forest communities in the CB rely on the forest for their livelihood and enjoy customary rights over their land. Hence, the expansion of palm plantations without appropriate social safeguards will likely place these communities in the same position as their Indonesian counterparts.

However, experts stressed that conflicts can be avoided. The seeking of consent of concerned communities by the state or biofuel companies could actually eliminate conflict over land. Cameroon for instance has operational FPIC guidelines for REDD+ which contains principles and procedures which must be followed by a project proponent during the process of seeking the consent of indigenous and local communities, and criteria and indicators which could be used to verify if the FPIC exercise was carried out as per the laid down procedures. These FPIC guidelines could also be used by biofuel companies seeking the consent of communities on whose customary land biofuel crop plantations will be established. Under circumstances where a community gives their consent for establishment of a plantation on their land and the biofuel company respects the terms of the agreement accompanying the consent, there is less likelihood for the occurrence of conflict.

Environmental impacts of biofuel crop production

Respondents (88%) agreed that biofuel crop production in central Africa is a big threat to forest cover and biodiversity

conservation. This corroborates the study conducted by Zaman *et al*. (2016) who found that biofuel production in Sub-Sahara Africa is associated with the depletion of natural resources and biodiversity loss. In addition to the impact of biofuel on forest cover change, its production is associated with degrading water quality which is brought about by an increase in the sedimentation and nutrient load of water bodies that occurs as biofuel crop plantations are expanded (Yasarer *et al*. 2016). Despite the growing concerns about the impacts of biofuel crop production on the environment, it is still however agreed that biofuel crops can be produced with limited impacts on the environment, biodiversity and ecosystem services. Experts in the Congo Basin noted that impacts on forests ecosystems can be avoided by practising integrated land use planning methods.

Land use planning is recognised as a measure that could be employed in order to lessen or eliminate the likely impact of development projects on forest cover (Enongene and Fobissie 2016). Land use related policies should give high priority for the selection of degraded and low carbon land for the implementation of development projects (Tegene *et al*. 2016) since this will reduce pressure on the natural forest. In the REDD+ strategy of some the participating REDD+ Congo Basin countries, land use planning is highlighted as a cross-cutting strategic option that might help limit the impact of agricultural activities among others on forest loss. However, some experts argued that, integrated land use management is plausible theoretically but appears very challenging in practice, especially on a large scale.

Ongoing oil palm expansion initiatives in Cameroon, the Republic of Congo and the DRC are being carried out amidst strong criticisms of their environmental integrity. This situation has been attributed to the weakness of existing environmental protection policies. These countries have national strategies to guide companies to reduce environmental impacts albeit they are implemented with mixed results. In Cameroon for instance, Law No. 96/12 of August 5, 1996 relating to environmental management prescribes that a proponent of an activity that is likely to impact on the natural environment is liable to examination by an environmental impact assessment. Some experts (58%) interviewed expressed dissatisfaction with the procedures and the implementation of these environmental policies. The implementation process is characterised by weak governance (Mboringong and Enongene, 2015), corruption, inadequate accountability and transparency, weak enforcement, and lack of technical and financial capacity. For example in the Republic of Congo, it was mentioned that due to some unclear reasons e.g. cost, technical capacity and time, government related projects are not subjected to strict environmental scrutiny in terms of carrying out environmental impact assessments.

Most of the respondents (73%) agreed that it is possible to reconcile biofuel crop production with forest and biodiversity conservation for climate change mitigation. Biofuel has potential for mitigating climate change through its role in substituting fossil fuel but, if not well regulated, the expansion of biofuel crop plantations could drive forest loss and carbon emissions. In the DRC, it was mentioned that old abandoned plantations can be revived in order to avoid expansion of plantations into forest areas. Furthermore, it was stressed that degraded lands can be exploited for the establishment of new plantations. This is in agreement with the views of Edrisi and Abhilash (2016) who argue that the use of marginal and degraded land for bioenergy production constitutes a sustainable solution for meeting society's energy requirement. Using degraded and low carbon land for growing biofuel crops will not only make the degraded land more productive but will also prevent the expansion of plantations into natural forested areas which constitutes area of high conservation value. At the moment none of the countries have a strategy that encourages agriculture investments in degraded lands. It was stressed that agriculture investments in degraded lands may be expensive financially and technologically challenging.

Rendering biofuel crop production more sustainable in the Congo Basin

According to experts, if carefully planned the development of biofuel crops can contribute to economic development and poverty reduction in the region. Otherwise, plantation expansion for biofuel may lead to loss in high conservation value areas and negative impacts on the livelihoods of local communities and indigenous peoples. There should be efforts to reduce the negative impacts of the expansion and to increase the positive impacts. In this context, actors argue that all relevant stakeholders e.g. government ministries, international and local NGOs, companies and local communities need to organise and develop a national strategy that can direct the rapid growth of biofuel crop plantations and ensure that expanded production contributes to the sustainable development agenda of the region. The region can borrow positive experiences from leading producing countries. Proposals for a sustainable strategy include the revitalization of abandoned/existing plantations to increase productivity and yields. For instance, the provision of improved inputs and harvesting techniques, the expansion of biofuel crop production in degraded lands in order to reduce impacts on biodiversity and carbon stocks, the provision of incentives and motivation to companies to encourage investments in degraded lands e.g. subsidies, subventions, research etc., the expansion of future plantations should be obliged to adopt and implement guidelines of existing standards such as the Roundtable on Sustainable Palm Oil (RSPO), the revision of existing tenure arrangements in order to provide protection and security to local land rights.

Policy implications

The initial finding was that there is a lack of a national strategy or policy that regulates the production and consumption of biofuels in the Congo Basin. Congo Basin countries are currently reflecting on the elaboration of their respective national biofuel strategies and experts in the three Congo Basin countries visited were of the opinion that they have not been included in the process. The development of the biofuel policy is led by a focal ministry in each country. Albeit a

single ministry takes the lead for the elaboration of the biofuel strategy in the respective countries, the biofuel sector is multi-sectorial. Using Cameroon as an example, while the Ministry of Energy and Water represents the focal institution for biofuel, the cultivation of biofuel crops would fall under the jurisdiction of the Ministry of Agriculture and Rural Development. The lack of inter-ministerial coordination is likely to conclude in conflicting goals and this corroborates the findings of Mboringong and Enongene (2015) which holds that inter-ministerial coordination lapses between government ministries will likely emerge between ministries with diverse sectoral agendas. For example, environmental protection and extraction, and food production and forest conservation etc. Hence, the elaboration process of the biofuel strategy in each Congo Basin country should be participatory and inclusive, involving relevant actors from different sectors including but not limited to key government ministries, the private sector, civil society organizations, international non-governmental organizations, education and research institutions. Most of the experts interviewed agreed that countries of the region have inadequate technical and financial capacity to elaborate and implement a comprehensive biofuel strategy. Technical and capacity building support to ministerial staff among other actors in the Congo Basin countries is therefore a prerequisite for the elaboration of an effective biofuel policy.

Second, our findings suggest that although biofuel production in the Congo Basin has potential to produce undesirable impacts on the environment, food security and local and indigenous communities, these impacts can be avoided or lessened. The expansion of palm plantations in the Congo Basin presents great opportunities for economic growth on one hand but constitutes a threat to the forest and biodiversity resources on the other. The emerging REDD+ initiative also appears as a promising source of finances for the participating REDD+ countries, and Cameroon and the DRC for example see REDD+ as a tool that will foster economic and social development in their respective countries. Ironically, planned and ongoing expansion of palm plantations in the Congo Basin occurs in forested areas and this could result to a scenario where REDD+ interventions conflict with those of biofuel crop expansion. For the undesirable impacts of biofuel expansion to be mitigated, there is need for good inter-ministerial/sectorial coordination in the different Congo Basin countries to ensure the alignment and harmonization of different sectorial policies and strategies thereby minimizing the possibility of conflict. This is in line with the studies conducted by Enongene and Fobissie (2016) who found that the appropriate coordination between REDD+ institutions and those of the green economy is instrumental in avoiding conflicting goals and maximizing synergies between the two concepts.

Third, our study revealed that although there exist environmental policies and strategies geared towards ensuring the environmental sustainability of development projects, these policies are not satisfactorily implemented. This is accounted for by weak governance and corruption that prevails in the countries of the Congo Basin. It is therefore evident that the elaboration of sound policies is not sufficient to achieve anticipated outcomes. The strengthening of governance and proper law enforcement in the Congo Basin countries is indispensable for the effective regulation of the activities of the emerging biofuel sector.

CONCLUSION

Biofuel is increasingly gaining attention as a more environmentally friendly fuel and consequently as a substitute for fossil fuels. While biofuel is known to have climate change mitigation potential its relationship with food production, biodiversity loss and threats to land security and conflict is raising concerns. Plans to expand palm plantations are underway in the Congo Basin region, and areas with high carbon stocks and rich biodiversity are the targeted areas for expansion. Indigenous and local communities who rely on customary rights over land are facing tough times to protect their lands from agro-industries.

Currently, there is no national policy objective and/or strategy that directs the production and consumption of biofuels in the Congo Basin countries. There is an ongoing large scale expansion of biofuel crop plantations in the Congo Basin, but limited information exists on the investments related to biofuel crops and biofuel production in general. On-going efforts in the biofuel policy domain have not yet set a broad base multi-sectoral and multi-actor institutional arrangement or platform for the development of a sustainable biofuel production and consumption strategy. Conflicts between government ministries over the control of the biofuel sub-sector abound. This is further exacerbated by insufficient technical and financial capacity for countries to rapidly undertake the elaboration and implementation of a comprehensive biofuel strategy.

Based on experts' opinion in the Congo Basin, the agricultural sector of Congo Basin countries has potential to provide both food and biofuel production in spite of the absence of clear strategies that provide guidelines for ensuring the balance between food security and biofuel production.

Biofuel production in the Congo Basin is likely to drive land conflict between companies and local and indigenous communities that rely on customary rights over land but these conflicts can be avoided by drawing from experience in other countries. The cultivation of biofuel crops is a major threat to the Congo Basin forests but impacts on the forest can be mitigated by practising integrated land use planning methods and encouraging agriculture in degraded lands.

While countries in the Congo Basin have national strategies to guide companies to reduce environmental impacts, many actors are not satisfied with the procedures and the implementation of these environmental rules. However, experts consider that it is possible to reconcile biofuel crop production with forest and biodiversity conservation for climate change mitigation and if carefully planned, the development of biofuel crops can contribute to climate change mitigation, economic development and poverty reduction in the region.

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Bioenergy production and land use changes in the context of the food-fuel-fibre nexus and climate change in West Africa

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SUMMARY

This study sought to evaluate bioenergy production and land use changes in the context of food, fuel and fibre and climate change in West Africa. The study was carried out in Ghana, Nigeria, Niger and Mali. Secondary data for the study were gathered from documents obtained from governmental Ministries, Departments and Agencies, libraries and the internet. Data collected were subjected to content analysis and descriptive statistics. Logging, timber export, agriculture and collection of wood for fuel are the chief causes of deforestation in the countries. Deforestation, environmental degradation, soil and water contamination, loss of farmland and livelihoods as well restiveness are some of the effects of mining and logging in the studied countries. While charcoal and firewood were the major sources of bioenergy in the studied countries, cultivation of Jatropha for bioenergy was reported to largely impact positively on biodiversity, food and land security in Mali, but has both positive and negative effects in Ghana. The effects of bioenergy development on food security, land security, biodiversity and fibre production might show net gains if bioenergy development is properly planned with effective engagement of all stakeholders and strong institutional and policy frameworks.

Keywords: deforestation, food security, bioenergy, resource extraction, climate change

Production bioénergétique et changement de l'utilisation des terres dans le contexte des liens alimentation-combustibles-fibres et du changement climatique en Afrique de l'ouest

O.J. AJEWOLE et M. LARWANOU

Cette étude a essayé d'évaluer les changements de la production bioénergétique et des utilisations de la terre dans le contexte de l'alimentation, des combustibles et des fibres, ainsi que dans celui du changement climatique en Afrique du Sud. L'étude a été menée au Ghana, au Nigéria, au Niger et au Mali. Les données secondaires de l'étude avaient été recueillies à partir de documents obtenus des ministères, départements et agences gouvernementaux, des bibliothèques et de l'internet. Les données rassemblées ont été soumises à une analyse de leur contenu et à des statistiques descriptives. L'exploitation du bois, l'export de bois, l'agriculture et le ramassage de bois à usage combustible sont les causes principales de la déforestation dans ces pays. Cette déforestation, la dégradation environnementale, la contamination de l'eau et du sol, la perte de terres arables et de sources de revenus, ainsi que la réactivité sont certains des effets produits par l'exploitation minière et celle du bois dans les pays étudiés. Alors que le charbon et le bois de chauffage étaient les sources majeures de bioénergie dans ces pays, on a remarqué que la cultivation du Jatropha à usage bioénergétique impactait d'une manière largement positive la biodiversité , la sécurité alimentaire et celle de la terre au Mali, mais qu'elle avait des effets à la fois positifs et négatifs au Ghana. Les effets du développement de la bioénergie sur la sécurité alimentaire, la sécurité des terres et la production de fibres pourraient obtenir de gains nets si ce développement est planifié convenablement, avec un engagement efficace de toutes les parties prenantes dans des cadres institutionnels et politiques solides.

La producción de bioenergía y los cambios en el uso de la tierra en el contexto del nexo entre alimentos, combustibles y fibras y el cambio climático en África Occidental

O.I. AJEWOLE y M. LARWANOU

El objeto de este estudio fue evaluar la producción de bioenergía y los cambios en el uso de la tierra en el contexto de los alimentos, el combustible y la fibra, y el cambio climático en África Occidental. El estudio se llevó a cabo en Ghana, Nigeria, Níger y Malí. Los datos secundarios para el estudio se obtuvieron de documentos obtenidos de Ministerios, Departamentos y Agencias gubernamentales, bibliotecas e Internet. Los datos recogidos se sometieron a un análisis de contenido y a estadística descriptiva. La tala, la exportación de madera, la agricultura y la recolección de madera para combustible son las principales causas de la deforestación en estos países. La deforestación, la degradación

del medio ambiente, la contaminación del suelo y del agua, la pérdida de tierras para la agricultura y de los medios de vida, así como la intranquilidad, son algunos de los efectos de la minería y la tala forestal en los países estudiados. Mientras que el carbón vegetal y la leña eran las principales fuentes de bioenergía en los países de estudio, se reportó que el cultivo de Jatropha para la producción de bioenergía tuvo un impacto positivo en la biodiversidad, la seguridad alimentaria y de la tierra en Malí, pero tuvo efectos tanto positivos como negativos en Ghana. Los efectos del desarrollo de la bioenergía en la seguridad alimentaria, la seguridad de la tierra, la biodiversidad y la producción de fibra podrían mostrar beneficios netos si el desarrollo de la bioenergía se planifica adecuadamente con la participación efectiva de todas las partes interesadas y con marcos institucionales y de políticas que sean robustos.

INTRODUCTION

The estimates by International Energy Agency (INA) in 2013 indicated that in 2011 about 2.64 billion people, approximately 38% of the global population, relied on biomass energy, mostly fuel wood, for cooking and heating. Sub-Saharan African countries account for 26% of the global population, with around 79% of their population relying on biomass energy for cooking and heating (IAASTD 2008, Mirzabaev *et al.* 2014). Studies have also shown that biomass accounts for more than 60% of final energy use in Africa, 34% in Asia, and 25% in Latin America (Hazel and Pachauri 2006). Biomass has become one of the most commonly used renewable sources of energy in the last two decades, second to hydropower in the generation of electricity. Due to its low cost and indigenous nature it accounts for almost 15% of the world's total energy supply. The share of biomass energy in total energy consumption varies across developing countries, but generally the poorer the country, the greater its reliance on traditional biomass resources.

Bioenergy, as compared to other renewable energy sources potentially offers many advantages if properly managed. These include, but are not limited to, renewed investment in the agriculture sector, rural development opportunities, job creation, and increased energy security and access, as well as increased income (FAO 2014). Other advantages of bioenergy include reduced production of greenhouse gasses such as methane and sulphur dioxide, prevention of forest fires, improvement of air quality, reliability, recyclability, renewability, reduction in the levels of emissions, cleaner environment, abundance, carbon neutrality, cost effectiveness, less harmful emissions, cleanliness, reduced dependency on fossil fuels, reduced landfills, obtainable from diverse sources, versatility and reduction in waste (Maehium 2012).

However, despite the exciting prospects for bioenergy, there are issues that call for serious concern due to the implications of bioenergy production and use on the poor, the environment and food security. First, as energy production competes with food for harvests and land, food production declines and prices increase. There are concerns that this competition could affect food security as food crops may be used as fuel, and agricultural land may be used for feedstock production. Moreover, the increasing demand for biofuels is likely to increase the cost of land, labour, and agricultural inputs. Furthermore, the use of trees as feedstock to produce biomass energy on a large scale can lead to widespread deforestation, degradation, desertification and loss of biodiversity since large amounts of wood and other waste products have to be burned in order to produce considerable amounts of bioenergy. For example, trees, which are not very suitable for charcoal production, might be felled to produce charcoal whenever there is scarcity of suitable tree species; an issue that is of particular concern due to the role of forests in carbon sequestration (Greentumble 2016). In addition, the production of some biomass energy crops, such as corn and wheat to make ethanol, can have negative consequences if too much of a food crop is diverted to produce biomass energy.

Another growing concern in bioenergy is global climate change and the need to reduce greenhouse gas emissions. Although bioenergy is frequently thought of as a carbon-neutral source of energy that could do much to reduce carbon emissions it also requires fossil fuels for growing, transporting and processing the feedstock, and for refining and distributing the biofuel. Depending on the type of feedstock, and on where and how it is grown and used, the net carbon balance can vary widely, hence net carbon and energy savings are not assured.

Beyond issues related to carbon balances, bioenergy crops and plantations present their own local environmental challenges for soil, water, and biodiversity management (IAASTD 2008). Notably, a third of the land sold or acquired in Africa is intended for fuel crops estimated at about 5 million hectares. Agro-fuels are competing with food crops for farmland, and associated development companies are competing with farmers for access to such land. This appears to be as much the case for Jatropha, as for other crops, despite the claim that it grows on non-agricultural land. When losing their access to traditional land local communities face growing food insecurity and hunger as their right to food is threatened. Pressure on farmland has led to forests being cleared to make way for agro-fuel plantations, destroying valuable natural resources and increasing greenhouse gas emissions For instance, in Ethiopia, land inside an elephant sanctuary was cleared to make way for agro-fuels (Friends of the Earth Europe 2010).

Biomass has considerable potential to become more important in total energy consumption, but this growth can have significant impacts, both positive and negative, on agriculture and its relationship to the poor (Karekezi and Kithyoma 2006). Concerns have also been raised about the economic viability as well as the environmental and social sustainability of bioenergy systems. Moreover, an expansion of bioenergy production from agricultural and forestry sources also generates concerns over land use management and governance within the context of growing demands for food resulting from increasing global population and wealth.

A clear understanding of the linkages between bioenergy production and use, sustainability and food security is needed in order to inform the development and implementation of bioenergy policies that will contribute to both energy and food security in a sustainable manner (FAO 2014).

This paper addresses the trends of forest cover change and drivers of deforestation and forest degradation, impact of natural resource extraction on food, fuel and fibre in the context of climate change, bioenergy development and impact on food production, land security and biodiversity, and policies and strategies to make the bioenergy industry a viable business in four West African countries; Ghana, Nigeria, Niger and Mali. It also indicates best practices that can enhance sustainable use of biomass energy for socio-economic development which is essential as a tool in building resilience to climate change in West Africa and across the African continent.

METHODOLOGY

Data collection and analytical approaches

This study was carried out in four West African countries: Ghana and Nigeria representing the humid or the forest zone, and Niger and Mali, representing the dry zone or the Sahel. Secondary data for the study were gathered from documents obtained from governmental Ministries, Departments and Agencies, libraries and the internet. Some of the MDAs (Ministries, Departments and Agencies) visited to solicit for information included the Federal Department of Forestry, Ministry of Environment, Abuja in Nigeria; Ministry of Lands and Natural Resources, Accra, Ghana; Ministry of Food and Agriculture, Accra; the Ghana Energy Commission, Accra; Ministere de l'Environment, de la Salubrite Urbaine et du Development Durable, Niamey, Niger; Comite National du Code Rural, Niamey, Cabinet du Premier Ministre, Counseil National de I'Environment pour un Development Durable (CNDD), Secretariat Executif, Niamey;Ministere del'Energie et l'Eau, Direction Nationale de l'Energie, Bamako, Agence Malienne pour le Développement de l'Energie Domestique et l'ElectrificationRurale (AMADER), Bamako, Mali; and Project de Promotion de l'Utilisation de l'Huile de Jatropha comme Biocarburant au Mali, Bamako. Data collected were subjected to content analysis and descriptive statistics.

RESULTS AND DISCUSSION

Trends in forest cover change

The percentage of land area under forestry development between 1990 and 2015 decreased in all the studied countries with the exception of Ghana, while agricultural land area increased within the same period in all the countries studied (Tables 1 and 2). Ghana's share of land area under agriculture increased by 19.7%, while that of the forest area increased only by 3.1%. Nigeria recorded the highest decrease (-11.2%) in the forest land area within the period of study (World Bank, 2016a 2016b). According to World Atlas (2016), Nigeria has the highest rate of deforestation in Africa, which the FAO (2015) put at 3.5%. This is followed by Niger (2.1%) and Mali (1.4%).

Logging, timber export, subsistence agriculture and collection of wood for fuel and charcoal production, oil and solid mineral exploration as well as urbanization are the chief

TABLE 1 *Agricultural land and forest area as percentage of land area in four West African countries*

Country	Agricultural land (% of land area)			Forest area (% of land area)		
	1990	2015	Net change	1990	2015	Net change
Ghana	55.4	69.0	19.7	37.9	41	3.1
Mali	26.3	33.8	22.0	5.5	3.9	-1.6
Niger	26.1	36.1	27.7	1.5	0.9	-0.6
Nigeria	67.6	77.7	13.0	18.9	7.7	-11.2

Source: World Bank (2016a and b): Agricultural land (% of land area), Forest area (% of land area).

TABLE 2 *Forest cover change in four selected countries between 1990 and 2015*

Country	Forest area (1000ha)					Annual change rate							
						1990–2000		2000–2010		2010–2015		1990–2015	
	1990	2000	2005	2010	2015	10^3 ha/yr	%	10^3 ha/yr	%	10^3 ha/yr	%	10^3 ha/yr	%
Ghana	8627	8909	9053	9195	9337	28.2	0.3	28.6	0.3	28.4	0.3	28.4	0.3
Nigeria	17234	13137	11089	9041	699	-409.7	-2.7	-409.6	-3.7	-409.6	-5.0	-409.6	-3.5
Mali	6690	5900	5505	5110	4715	-79.0	-1.2	-79.0	-1.4	-79.0	-1.6	-79.0	-1.4
Niger	1945	1328	1266	1204	1142	-61.7	-3.7	-12.4	-1.0	-12.4	-1.1	-32.1	-2.1

Source: Adapted from FAO (2015): Global forest resources assessment 2015

causes of deforestation in Nigeria (Ogunwale 2015), whereas in Ghana underlying causes of deforestation include poverty, ignorance, corrupt practices of governments, security and forestry officials, weak institutions, inappropriate policies, lack of law enforcement, lack of concern by local communities as well as land tenure issues (Guuroh 2011), while major causes are forest clearance for cocoa and food crop farms as well as legal and illegal logging (Nsenkyire 1998). Similarly, the causes of deforestation in Mali comprise land clearance for agriculture as well as meeting the country's demand for fuel and timber. This high rate of deforestation has effects on agriculture and serves as a catalyst to degradation and desertification, as soil fertility declines and erosion accelerates (Treeaid 2015, Savadogo *et al*. 2017).

Deforestation, the second largest anthropogenic source of carbon dioxide to the atmosphere, after fossil fuel combustion (Van Der Werf *et al.* 2009) is considered to be one of the contributing factors to global climate change by reducing the amount of carbon stored and also releasing carbon dioxide into the air.

In general, trends in forest cover change are associated with social, economic and environmental factors (FAO 1999). Prior to the industrial era, forest clearances were generally part of a relatively slow and steady process but in recent times the rate of deforestation around the globe has dramatically increased. Conversely, forest areas can be increased through afforestation, reforestation or by natural expansion of forests. The planting of trees has resulted in new forests being established while in other areas forests have expanded into abandoned agricultural land through natural regeneration, thus reducing the net loss of total forest area (UNEP 2006).

Impact of extractive industries on the food, fuel and fibre nexus in the context of climate change

Mining

In Nigeria, deforestation, forest degradation and crop land contamination resulting from extractive activities have given rise to continuous restiveness, community agitation and militancy. According to Schueler *et al.* (2011), deforestation, substantial loss of farmland within mining concessions, loss of livelihoods for women subsistence farmers and widespread spill-over effects as relocated farmers expand farmland into forests have been the major consequences of resource extraction in Ghana. Moreover, illegal miners sneak into forest reserves at night to exploit land for mineral wealth in protected forest areas. These inappropriate practices by illegal miners are causing loss of timber resources, land degradation and cyanide pollution of soil and water bodies. Furthermore, Kløcker *et al.* (2013) observed that the impacts of uranium exploitation in Niger Republic include pollution of land and water resources with radioactive waste and toxins, irreversible damage to the sandstone aquifers in near and mid-term future as well as the appropriation of pastoral livestock corridors and grazing territories without compensation. Likewise, land expropriation, environmental degradation and social tensions were observed to be parts of the effects of mining in Mali Republic.

Resource extraction whether on an artisanal or industrial scale causes adverse effects on the environment. The impact of resource extraction can include the introduction of invasive alien species through transport operations, the expansion of agriculture into natural forests, expanded illegal logging (UNEP 2016), and high levels of atmospheric pollution, which damages crops and causes severe health problems. Large-scale mining operations, especially those using open-pit mining techniques, can result in significant deforestation through forest clearing and the construction of roads which open remote forest areas to transient settlers, land speculators, and small-scale miners. Strip mining is also problematic as it eliminates existing vegetation, destroys the genetic soil horizon, displaces or destroys wildlife and habitat, alters current land uses, and to some extent permanently changes the general topography of the area mined. Furthermore, artisanal miners use the forest and its resources for food, construction materials and energy. Moreover, large numbers of miners usually descend on a previously untouched forest area to explore and extract its minerals and cause significant damage to the forests. The construction of transport infrastructure may also open up remote forests to other activities, such as logging, hunting and agriculture.

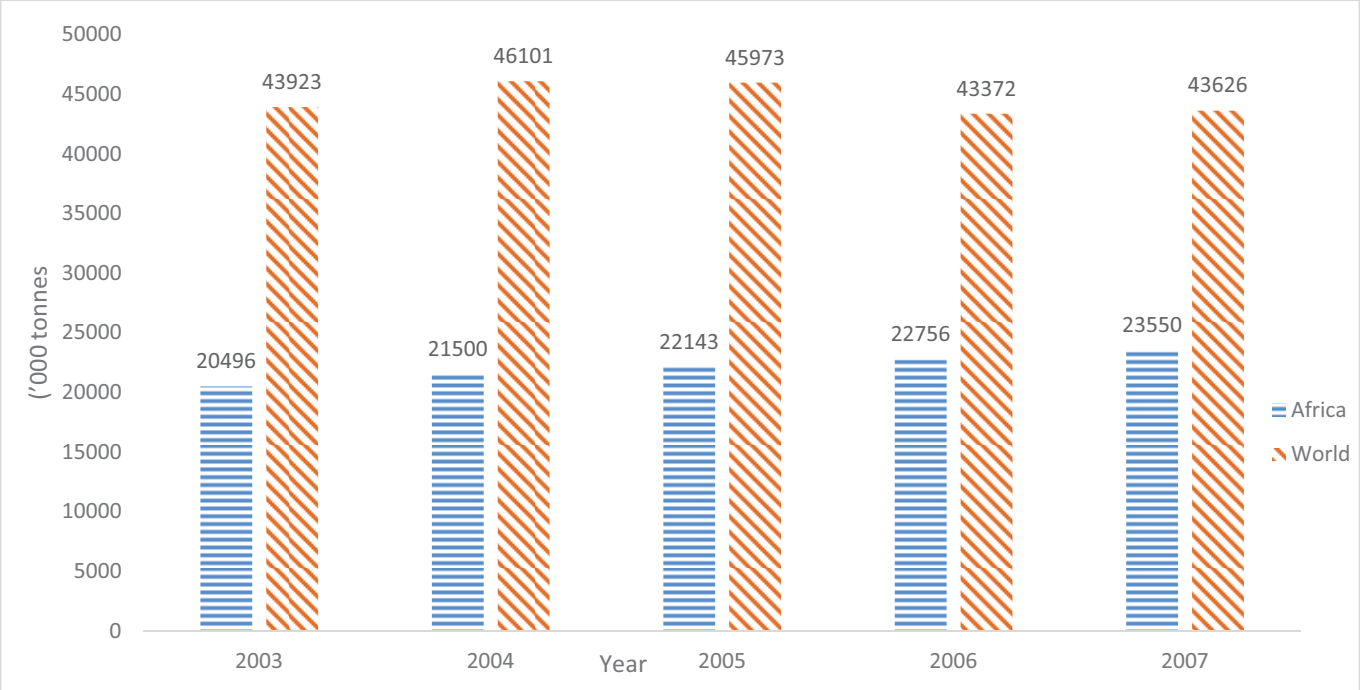
Logging

The 1998–2002 G8 Action Programme on Forests highlighted illegal logging as one of five issues affecting the world's forests (European Forest Institute, 2014). Illegal logging, which often results in significant loss of government revenue, undermines efforts to place the forest sector on a more sustainable footing, as lost revenue cannot be reinvested in the sector. Furthermore, because illegal logging is often unsustainable, future sources of employment and export revenues are not realized. Illegal logging distorts global markets and undermines incentives for sustainable forest management, as illegal timber is often cheaper than legal timber. Illegal logging undermines the rule of law and is often associated with corruption. Moreover, it may entail a lack of recognition of the land and resource use rights of forest communities, or of the rights of other concession-holders which can have negative impacts on the livelihoods of local people and result in conflict (Chatham House 2016).

Logging in Nigeria is shrouded in controversy, corruption and illegality (Fameso 2013, Oyerinde 2013). According to Aiyetan (2016) poor regulations and monitoring as well as local corruption *'have created a thriving illegal trade in timber from Nigeria and a large part of West Africa to China, with grave consequences for the economy, ecosystem and the environment'*.

Logging has an overall adverse impact on the forest ecosystem in Nigeria. For instance, Cazzolla Gatt *et al.* 2015 observed that selective logging, if it is not practiced at very low harvest intensities, can significantly reduce the biomass of a tropical forest for many decades, seriously diminishing above-ground carbon storage capacity, and create opportunities for weeds and vines to spread and slow down the ecological succession. Oke and Oyadare (2008), Mfon and Bisong (2011), and Akintoye *et al. (*2013) also observed a considerable reduction in quality and quantity of

FIGURE 1 *African and World Consumption Pattern of Charcoal between 2003 and 2007*



Source: John Vos and Martijn Vis (2010): Making charcoal production in Sub Sahara Africa sustainable.

non timber forest products and unlogged tree species with increase in logging intensity.

Illegal logging and its associated trade in timber products has been a severe policy problem for Ghana resulting in significant reduction in forest cover, undermining the resource base of the timber industry, causing distress to the formal timber sector, resulting in a loss of revenue to land owners as well as government and creating degradation of the environment (Agyarko 2001, Hansen 2012, Teye 2013, Boakye 2015, Hance 2015). Hansen and Treue (2008) reported that 70% of the total harvest, or 2.3–2.7 million m^3 annually, is estimated to be illegally cut. Chainsaw operators, who supply most of the domestic lumber demand, account for two-thirds and the export oriented timber industry account for one-third of the illegal harvest. The most valuable timber species dominate the illegal harvest and they originate mostly from forest reserves, which results in them becoming seriously threatened. Illegal logging remains a considerable problem in Ghana, and a number of enforcement and administrative challenges persist. Weak law enforcement, poor domestic production standards, and a large export market have continued to drive illegal chainsaw milling in the country. Logging, both legal and illegal, remains a lucrative business that has contributed to the rapid shrinking of Africa's rainforests and woodlands.

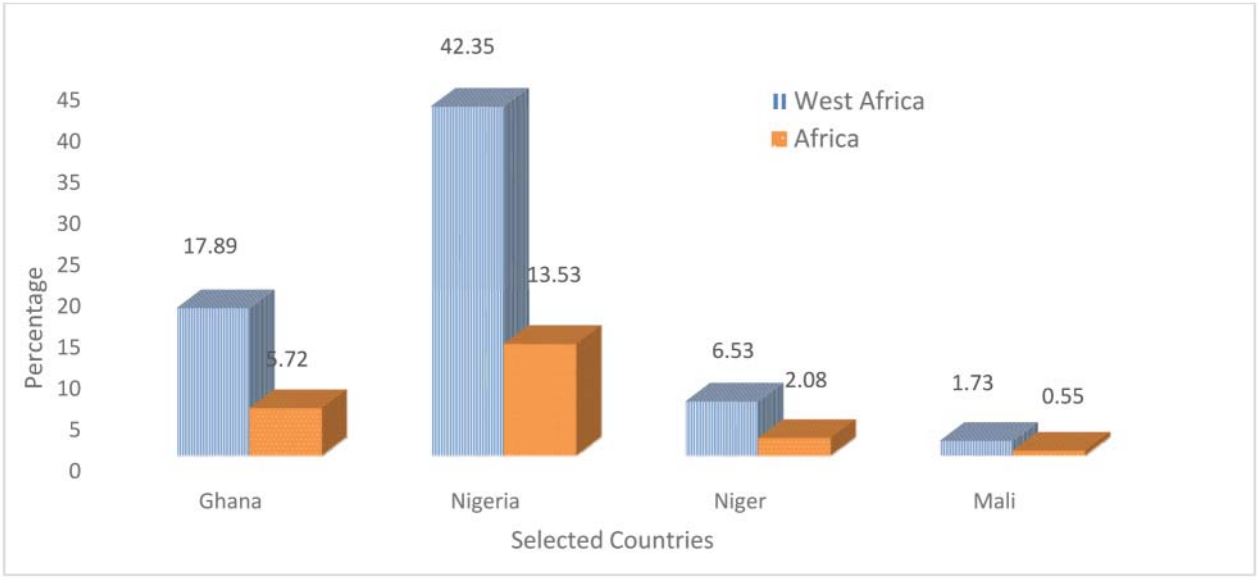
Charcoal production

The majority of urban households and a considerable number of rural households in many African countries depend on charcoal for their energy needs. Figure 1 shows shows that Africa alone consumed about half (49.53%) of the total world production of charcoal between 2003 and 2007 (John and Martijn 2010), while Figure 2 shows that Nigeria accounts for 42.4% and 13.5% of charcoal production in West Africa and Africa, respectively, followed by Ghana (17.9% and 5.7%), Niger (6.5 and 2.1%) and Mali (1.7% and 0.6%) (Knoena 2016). The forest zone countries in this study, Nigeria and Ghana, consume more firewood and charcoal compared to the savannah countries of Niger and Mali, due to their greater population and relative abundance of wood.

Charcoal production, which can be the result of farmers' clear felling of land for agriculture or through selective cutting or opportunistic harvesting of wood, contributes significantly to deforestation and forest degradation and can accelerate desertification processes in low rainfall areas where the forest's regenerative capacity is low. Charcoal producers' preference for slow-growing tree species that yield dense and slow-burning products makes those species particularly vulnerable to over-exploitation with consequent adverse effect on biodiversity. Moreover, some dense tree species which have a high economic value are unrecognized by the charcoal producers and are thus used for charcoal production, leading to great economic loss.

Charcoal production also has grave implications on climate change, because charcoal from most earth-based kilns which are commonly used in most parts of Africa is produced in an oxygen poor environment that results in the formation of products of incomplete combustion such as methane. Charcoal production therefore contributes to climate change through production and emission of greenhouse gasses such as carbon dioxide (CO_2) and methane (CH_4). Kammen and Lew (2005) and FAO (2017) argued that emissions during charcoal production have a greater global warming contribution than emission from the burning of charcoal. Estimates of

FIGURE 2 *Percentage Contribution of the Selected Countries to Charcoal Production in West Africa and Africa*



Source: Knoena (2016): AFDB Socioeconomic Database 1960–2016.

annual global GHG emissions from traditional wood energy (fuelwood and charcoal) are in the range of 1–2.4 Gt CO2e, which constitute between 2 and 7 percent to global anthropogenic emissions annually. Africa had the highest share (34%) of the total global CO_2 emissions from the production and use of wood energy (FAO, Ibid.). Chidumayo and Gumbo (2013) estimated the emissions of greenhouse gasses from charcoal production in tropical ecosystems in 2009 at 71.2 million tonnes for carbon dioxide and 1.3 million tonnes for methane. Africa because of the quantity of charcoal produced accounted for 65.6% of this global emission of greenhouse gasses from the tropical ecosystem. Chidumayo and Gumbo (ibid). also estimated from observations made on 11 kilns, emission factors (greenhouse gas/kg charcoal produced) of 1788 ± 337 for CO_2 and 32 ± 5 for CH_4. Furthermore, Bailis (2005), observed that the common practice of charcoal production in Kenya can lead to a loss of 2.7 tC per ton of charcoal produced based on life cycle assessment.

It is expected that demand for charcoal will further increase even in Sub Saharan African (SSA) countries where large volumes of charcoal are already being consumed because of population increase (often 2–3% per year, which leads to a doubling of the population in about 20 to 25 years), increased urbanization and rising prices for alternative fuels such as LPG, natural gas, or electricity which will cause people to continue using charcoal despite rising incomes. This situation will require that African countries put in place strategies to ensure sustainable production and use of charcoal.

The nexus of food, fuel and fibre and its impact on land security and natural habitat

The relationships among food, fuel and fibre are multidimensional and intertwined. Food security is one of the major concerns surrounding the use of biofuels. Energy plantations have direct impacts which include possible dispossession of land among the poor in areas with insecure land tenure, with attendant increases in poverty and food insecurity. Therefore, large-scale modern biomass energy development without appropriate, sensitive, and equitable management, can lead to further marginalization of the rural poor. Biofuel feedstock production competes with food, fibre and timber for land, water and fertilizers. There are concerns that this competition could affect food security, as food crops may be used as fuel and agricultural land may be used for feedstock production. As energy production competes with food for harvests and land, the production of food declines and the price of food goes up (UNECA-ACPC 2011). Moreover, intensive cultivation of energy crops is expected to produce adverse environmental impacts on soil and groundwater, and to result in deforestation and loss of biodiversity. On the other hand, the efficient exploitation of existing agricultural wastes presents significant potential for developing bioenergy without unduly disrupting existing agricultural practices and food production or requiring new land to come into production. Some of the most common crop wastes suitable for bioenergy development include sugarcane bagasse, sisal waste, coffee husks, rice husks, maize cobs and banana leaves. Unlike many other crop wastes, these waste products are generated during agro processing and are rarely returned to fields (Karekezi and Kithyoma 2006).

Studies have also shown that there is an increase in soil nutrients and organic matter in charcoal production sites in Nigeria and Ghana (Oguntunde *et al*. 2008, Ogundele *et al.* 2011, Oriola and Omofoyewa 2013). These results, however, differ from the work of Ogundele *et al.* (2012) due to the latitudinal position and slight climatic differences between humid and drier ecosystems as well as the type of kiln used in the production of charcoal. According to Kouami *et al.* (2009),

selective logging for charcoal production in Togo resulted in serious adverse effects on biodiversity and dendrometric characteristics such as density, height and diameter of the stands and basal area. This has a greater consequence in the savannas and dry forest biomass than in the semi-deciduous forests. Adedeji and Aiyeloja (2014) also observed that honeybees' habitats were considerably altered and there were increasing disturbance in the core niches of the forests by charcoal burners in Imeko, Nigeria. This has consequences on the quality and quantity of honey produced in the area.

Biofuel production in Ghana is an income generating venture with significant contribution to food security especially in the northern region of Ghana where farming is feasible for small-holder farmers only in the rainy season (Addo *et al.* 2014). Nevertheless, Boamah (2010) iterated that analyses of the effects of biofuels on food security should be situated within specific contexts, viz: local variations in land use patterns, land availability, farming seasons, household composition, and the resilience of livelihoods in biofuel producing areas, the strategy of biofuel investors as well as the biological characteristics of the biofuel feedstock. These factors determine the amount of resources that will be diverted from food production to biofuel production, which is in turn of fundamental importance in the debate surrounding competition between biofuels and food. Boamah (2010) observed that the organization of Jatropha plantations in three communities in Northern Ghana increased farmland areas under crop production during the project period compared to the period before it. Because of the Jatropha plants' suitability to marginal land, the Jatropha plantation was established on land abandoned by most farmers. Moreover, some portions of the Jatropha plantation, such as the Jatropha rows as well as the edges of the plantation, were used for maize production during the project. A total of 1100 ha of land was cleared of which 16 ha and 10 ha of maize farms were used for the communities and the workers of the company respectively. The outcome was that the Jatropha project reduced vulnerabilities in household food security in all the three Ghanaian villages whose livelihoods depended on the land areas earmarked for the Jatropha project. However, in other studies, Timko *et al.* (2014) as well as Acheampong and Campion (2014) observed that the cultivation of Jatropha plantations yielded both positive and negative results in Ghana. The cultivation of Jatropha plantations in the country, though creating employment and increased incomes, has nevertheless led to decreases in household landholdings which precipitated negative impacts on household socio-economic status, food security, fallow periods, and fodder availability.

In Mali, both NGOs and European companies are producing biofuels feedstocks, mostly through small scale projects based in the immediate vicinity of the company's or NGO's processing facilities (IIED 2009). At community and household levels, Jatropha offers the potential to contribute to rural development and diversify farmers' livelihood strategies. It is widely used to demarcate field boundaries and avoid land tenure conflicts, to produce soap and to reduce soil erosion. Local communities' expectations remain high with regards to a future generation of revenues that would allow a shift between different capital assets and a diversification of farmers' livelihood strategies. Such revenues can be used to buy cereals in times of shortage, clothes, and school materials and to repair agricultural equipment.

Jatropha is also perceived as an "easy-to-grow" crop that could act as a substitute for cotton farming, providing a diverse and more immediate source of liquidity to face the problems experienced in the past decade in the Malian cotton sector (Favretto and Dougill 2012). Favretto (2013) observed that the cultivation of Jatropha in Mali does not pose a problem to food security since it is usually intercropped with cereals and grown on small scale, rather Jatropha apart from generating extra income to the farmers, is also used as a living fence to delimit food crops and mitigate soil erosion. Furthermore, Eijck *et al.* (2013) remarked that cultivation of Jatropha in Mali contributed to biodiversity enrichment when planted on fallow land, fertilizing food crops with the seed cake, and reducing soil erosion. However, in spite of the benefits, the conversion of fallow, savannah and high-biodiverse forest and woodland to Jatropha plantations remains a cause for concern.

Institutional arrangements for the development of bioenergy in the selected countries

Institutional arrangements for development of biomass energy encompass institutions and administrative structures such as ministries, departments, agencies, research institutes and organisations as well as policies, legislations and strategies that are directly or indirectly concerned with the development of bioenergy at national and sub-regional levels.

Bioenergy development in most of the ECOWAS Member States follows an *ad-hoc* and unsustainable path. This is due to weak legal and regulatory regimes and enforcements for wood and charcoal production and trade, lack of, or inadequate, clear-cut policy on bioenergy development, lack of capacities of institutions and individuals in the member states, lack of adequate information and data for planning and investment, lack of awareness of the resource potentials and benefits for bioenergy use and investment opportunities, lack of financing opportunities and investment programmes, and lack of demonstration projects that showcase the socio-economic and technical feasibility of bioenergy projects for regional scaling-up (ECOWAS Regional Centre for Renewable Energy and Energy Efficiency – ECREE, 2013).

Nevertheless, extant regional and sub-regional institutional frameworks for the development of bioenergy include the ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE 2010), the ECOWAS Bioenergy Strategy Framework (2012), West Africa Clean Cooking Alliance (WACCA 2012), and the ECOWAS Bioenergy Policy (2015). The other two sub-regional noteworthy initiatives in the Sahel of West Africa include the Programme Régional de Promotion des Énergies Domestiques et Alternatives au Sahel (PREDAS), implemented by the Permanent Interstate Committee for Drought Control in the Sahel (CILSS) and the state members of ECOWAS, and the Programme Régional Biomasse Énergie (PRBE) implemented by the ECOWAS/UEMOA (Yeboa 2015).

In Niger Republic, bioenergy development constitutes the greater part of strategies for development of renewable and domestic energies since the energy sector is dominated by high consumption in the residential sub-sector, which is mainly based on wood resources (Reegle 2013a). The Directorate of Renewable Energy and Domestic Energy (DERED) in the Ministry of Energy and Petroleum is responsible for promoting and coordinating the use of renewable energies as part of the national strategy to enhance access of bioenergy resources in order to achieve an efficient management of wood and other sources of domestic energy. The other two major strategies formulated for the development of biomass energy in Niger Republic are the National Renewable Energies Strategy (La Stratégie Nationale sur les Énergies Renouvelables (SNER) and the National Strategy for Domestic Energies (La Stratégie Nationale des Energies Domestiques (SNED). (Centre d'Echange d'Informations sur la Biodiversité du Niger 2016).

Similarly, biomass energy accounts for 78% of the national energy supply in Mali, putting bioenergy development in the frontline of all the action plans for energy development. Mali is one of the few sub-Saharan countries with policies that encourage Jatropha cultivation (Favretto 2013). The Ministry of Environment & Sanitation (Le Ministre de l'Environnement et de l'Assainissement du Mali) is responsible for the promotion of renewable energy while the Ministry of Mines, Energy and Water (MMEE) through its specialized agencies which include the National Biofuel Development Agency (ANADEB), the Agency for the Development of Domestic Energy and Rural Electrification (AMADER) and the National Centre for Solar and Renewable Energies, is responsible for the production and use of Jatropha in the country. Essential support to the MMEE is provided by other major ministerial departments, including the Ministry of Agriculture, Ministry of Secondary and Higher Education and Scientific Research and Ministry of Industry, Investments and Trade, while the Malian National Strategy for Biofuels Development (NSBD) aims to increase local energy production by developing biofuels to meet the country's socio-economic needs and substitute imported oil (Reegle 2013b).

The Low Emission Capacity Building report (UNDP 2015) presented the relevant national and sector strategies and policies for biomass energy development in Ghana. This include the Bioenergy Policy for Ghana (2010), the National Energy Policy (2010) and the Ghana Sustainable Energy for All Action Plan (SE4ALL 2012).

The institutional arrangement specifically meant for bioenergy development in Nigeria is virtually non-existent. There are neither institutions nor strategies that focus on sustainable development of charcoal and firewood. Moreover, none of the Nigerian National Biofuels Programme and Policy of 2005 addressed the development of bioenergy, particularly charcoal and firewood. However, some initiatives exist, such as Energising Access to Sustainable Energy (EASE), to address the massive deforestation and cutting of trees for fuel wood. This initiative encourages planting of more trees and aims at improving the enabling framework conditions for renewable energy and energy efficiency in Nigeria and, in particular, with a focus on the use of renewable energies by Small and Medium Enterprises (SMEs) and households (Reegle 2014).

From the foregoing, it can be observed that the Sahel countries (Niger and Mali Republics) put a lot of effort into the development of bioenergy because of relative resource scarcity and the critical dependence of the majority of the populace on the wood-fuel resources. On the contrary, the countries in the forest zone (Ghana and Nigeria) did not pay much attention to bioenergy development because of the relative availability of wood-fuel resources and lower dependence compared to that of the Sahel countries on biomass energy as other energy sources such as fossil fuels are relatively available.

Strategies for development of viable bioenergy businesses using the Case of Rural Firewood Markets in the republics of Niger and Mali

Development of sustainable biomass energy will no doubt require the formulation of appropriate policies and strategies. Such a strategy is the development of Rural Firewood Markets (RFM) in the Republics of Niger and Mali. The RFM was developed to combat the problem of unsustainable exploitation of fuelwood in the Republics which was informed by the inability of the countries' Forest Service to effectively control and monitor the quantity of fuelwood cut by the firewood traders who had been given permit to cut a specified quantity of firewood from specific locations.

The goal of RFM was to check forest degradation and increasing desertification as well as to promote sustainable forestry development through controlled exploitation of forest resources. Under the RFM, an organized local management body charged with the responsibility of exploiting, guarding, managing and ensuring the regeneration of an agreed area of natural woodland supplying the market, signs an agreement with the government to manage woodland sustainably. The community is then given a formal control over its own area of natural woodland and exclusive rights to the sale of all the firewood produced from it.

Under RFM, the firewood cutting permit was abolished and, instead, the transport of harvested firewood to the towns became subject to taxation, called transport coupons. The transport coupons specify the amount, source (rural market/uncontrolled woodland) and the distance of the zone relative to the urban area from which the firewood has been obtained. The coupons served the purpose of providing a financial incentive to firewood traders to differentiate between the rural markets and uncontrolled zones as sources of supply, encouraging the firewood traders to patronize the controlled- over the directed-markets and encouraging dealers to obtain their supplies from further away, where forest resources were less heavily exploited than those close to the urban areas.

Between 40 and 60 % of tax revenues were assigned to the work of forest management such as agroforestry plantations, nurseries, firebreak, and fight against erosion. A share of the revenues was retained by the villages for development work. The rest was assigned to investments in the free choice of the villagers (Gerald *et al*. 2002).

The rural firewood markets in the Republics of Niger and Mali were an epoch-making and laudable strategy for development of viable bioenergy businesses in these countries. The establishment of the rural firewood market gave villagers exclusive control over their own woodlands, helped in mitigating forest degradation and resource wastefulness, contributed to biodiversity conservation, brought income to the villagers and increased tax revenues to the state. It is indeed a veritable instrument of sustainable forest management which can serve as a template for African indigenous forest certification and participatory forest development.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The production and use of biomass energy, especially fuelwood and charcoal, has been identified as one of the major causes of deforestation in the countries studied. This is because the current prevailing methods of charcoal production as a by-product of clearance of land for agriculture or through selective cutting ultimately brings about deforestation and forest degradation. In this regard it is important to state that biomass energy will continue to dominate energy demand particularly at household levels for cooking, heating and lightning in the studied countries as modern energy sources such as LPG, kerosene and electricity are not readily available or affordable by the majority of the populace, and alternative renewable energy is not yet at a significant level of development. Furthermore, extractive activities such as mining and logging which are largely characterised by corruption and illegality impact negatively on the environment, biodiversity, food and land security as well as community cohesion. Although, the Sahel countries (Republics of Niger and Mali) to a large extent have in place some institutions and strategies for the development of biomass energy, the situation is very different in the countries in the forest zone (Nigeria and Ghana) where biomass energy production is primarily in the informal sector. The lack of coherent policies and strategies for sustainable development of biomass energy make its production, transportation, and distribution unregulated with consequent challenges to sustainable management of the resources. For instance, it has been argued that the negligible portion of the African forest that is certified (1.1%), compared to 50.8% and 32.7% for Western European countries and North America respectively, has been a major factor contributing to illegal logging in Africa (Reboredo 2013).

The foregoing demands a more efficient method for the production and use of biomass energy, development of a relatively cheap alternative renewable energy to complement the use of biomass energy and the formalization of the biomass energy sector to serve as precursors to sustainable biomass energy development that is environmentally benign, economically efficient and socially beneficial. The effects of bioenergy development on food and land security, biodiversity and fibre production might show net gains if bioenergy development is properly planned with effective engagement of all stakeholders and if strong institutional and policy frameworks are put in place.

Recommendations

In order to reduce charcoal production-induced deforestation and forest degradation, wood for production of charcoal should be harvested from purposely established plantations. It is therefore imperative for forest development organizations to partner with national governments in Africa and development agencies to encourage communities, groups and individuals to establish agroforestry plots, woodlots and forest plantations planted with fast growing multipurpose energy trees on marginal, degraded or fallow lands using a business model approach which canvasses for the use of dedicated plantations for the sustainable production of charcoal. The model according to NOTS (2012) consists of two main pillars: (I) efficient charcoal ovens (retorts) for increasing efficiency of production, and (II) an agroforestry system for the production of wood (80%) and food crops (20%). The advantages of such a model include (a) bringing an end to charcoal-driven deforestation, (b) production of sufficient charcoal and food for the participating communities, (c) an increase in income by at least 20% for the participating community with recuperation of initial investments in less than three years. The implementation of the business model must however be guided by reports by Cramer (2007) and the World Energy Council (WEC) (2010), which provide sustainability criteria for sustainable production of bioenergy (charcoal) to compensate for possible deleterious effects of bioenergy production. Charcoal production using a plantation of fast growing species can also serve as climate change mitigation measures. For instance, Bailis, (2005) reported that a plantation of *Eucalyptus grandis* managed on a 10 year coppice cycle resulted in a net sink of 150 tC per ha or 0.5–0.8 tC sequestered per ton of charcoal produce.

Another way to alleviate deforestation and forest degradation informed by the production and utilization of wood-fuels is to promote sustainable ways of using wood for biomass energy. These include the use of energy efficient stoves, and conversion of agricultural and wood wastes to high calorie bioenergy such as briquettes or ‘green charcoal’, which can be produced by compressing agricultural waste into carbonized briquettes and has the look and feel of traditional charcoal as well as burning in a similar fashion. The technology is efficient, effective and economical, because it can produce a substitute for charcoal at half the price (IRIN 2016).

Furthermore, the menace of illegal logging, which is rampant in Ghana and Nigeria, can be mitigated by adopting the Rural Firewood Market concept—a somewhat microcosmic model of forest certification and public private participation—as a template for an African indigenous sustainable forest management model

Moreover, the four studied countries should put in place institutional frameworks and infrastructures to harness more

effectively the great endowment and potential for development of solar energy as a complimentary alternative renewable energy source to relieve pressure on biomass energy. Although, Niger and Mali Republics have a considerable level of development and use of solar energy more efforts are necessary to further entrench and increase its use in the countries, not only because it is renewable and environmentally friendly but also because increased use of solar energy will reduce the demand for biomass energy and consequently will not only reduce pressure on the land, but make more land available for food and fibre production.

In this regard the countries can access the facilities of the ECOWAS "SOLtrain West Africa", a thermal capacity building and demonstration programme. The SOLtrain programme aims at removing existing awareness, political, technological, and capacity-related barriers that has restricted solar thermal energy deployment in ECOWAS countries (ECREE 2013).

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Forestry sector engagement in climate change action: the role of public and private sectors in Zimbabwe

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SUMMARY

This study examined role of the Zimbabwean forestry sector in responding to climate change aiming at generating knowledge to facilitate development of public-private partnerships. The forestry sector is made up of primary, secondary and tertiary production actors. Plantation forests constitute 93.1% whilst agroforests (including woodlots) and natural forests have 5.7% and 1.2% respectively. About 60% of plantation areas are occupied by Pinus whilst Eucalyptus, *Acacia mearnsii* (wattle) and others constitute 29%, 10% and 1% respectively. All main primary actors have been harvesting larger areas than they were planting annually, making it unsustainable. However, they plan to increase the area planted to exceed annual harvested areas until a balance is reached to ensure a sustainable supply of wood. The private sector implements several forest-related adaptation and mitigation strategies, although some of the actors only focus on reducing emissions in industrial operations and survival rather than addressing climate change. Involvement in issues of forest carbon is limited to efforts by government and non-governmental organisations. Technical support for adaptation and performance of alternative species is needed to improve forest productivity.

Keywords: climate change, adaptation, mitigation, forestry, private public partnership

Engagement du secteur de la foresterie dans l'action pour faire face au changement climatique: le rôle des secteurs public et privé au Zimbabwe

L. MUJURU et V.O. OEBA

Cette étude a examiné le rôle du secteur forestier du Zimbabwe en réponse au changement climatique, visant à accroître les connaissances pour faciliter le développement de partenariats privé-public. Le secteur forestier est composé principalement d'acteurs primaires, secondaires et tertiaires. Les forêts de plantation constituent 93.1%, alors que les agro-forêts (comprenant les lots boisés) et les forêts naturelles atteignent respectivement 5.7% et 1.2%. Environ 60% des zones de plantation sont occupées par Pinus, alors que l'Eucalyptus *l'Acacia mearnsii* (acacia) et les autres espèces constituent respectivement 29%, 10% et 1%. Tous les acteurs primaires ont récolté des surfaces plus étendues que celles qu'ils plantent annuellement, rendant le processus non durable. Ils escomptent cependant accroître la surface plantée afin qu'elle excède les surfaces exploitées annuellement jusqu'à ce qu'un équilibre soit atteint pour assurer une fourniture de bois durable. Le secteur privé met en pratique plusieurs stratégies d'adaptation et d'atténuation liées à la forêt, bien que certains des acteurs ne se concentrent que sur la réduction des émissions dans les opérations industrielles et sur la survie, plutôt que de faire face au changement climatique. La participation dans les questions de carbone forestier est limitée aux efforts des organisations gouvernementales et non-gouvernementales. Un support technique pour l'adaptation et la performance des espèces alternatives est nécessaire pour améliorer la productivité forestière.

Participación del sector forestal en la acción contra el cambio climático: el papel del sector público y privado en Zimbabwe

L. MUJURU y V.O. OEBA

Este estudio examinó el papel del sector forestal de Zimbabwe en la respuesta al cambio climático con el objetivo de generar conocimientos para facilitar el desarrollo de asociaciones público-privadas. El sector forestal está compuesto por actores de la producción primaria, secundaria y terciaria. Los bosques de plantaciones constituyen el 93,1%, mientras que los sistemas agroforestales (incluidos los rodales para madera) y los bosques naturales son el 5,7% y el 1,2%, respectivamente. Alrededor del 60% de las áreas de plantación están ocupadas por Pinus, mientras que Eucalyptus, *Acacia mearnsii* y otros constituyen el 29%, 10% y 1% respectivamente. Todos los principales actores primarios han estado aprovechando áreas más grandes de las que plantaban anualmente, lo cual es insostenible. Sin embargo, planean aumentar el área plantada para que exceda el área aprovechada anualmente hasta que se alcance un equilibrio que asegure el suministro sostenible de madera. El sector privado aplica varias estrategias de adaptación y mitigación relacionadas con los bosques, aunque algunos de los actores sólo se centran en la reducción de las emisiones en las operaciones industriales y la supervivencia, en lugar de abordar el cambio climático. La participación en las cuestiones relativas al carbono forestal se limita a los esfuerzos de los gobiernos y las organizaciones no gubernamentales. Se necesita apoyo técnico para la adaptación y el rendimiento de las especies alternativas a fin de mejorar la productividad forestal.

INTRODUCTION

Forest and tree resources are a source of economic growth and employment, supporting over 1.6 billion people. The global trade in forest products contributes about US$270 billion of which more than 20 percent is from developing countries, with the forestry industries providing informal and formal employment opportunities to approximately fifty million people (World Bank 2008). Forests are also known to play a crucial role in reducing the impact of climate change that is projected to affect livelihoods of millions of people globally. The African continent is considered to be among the most vulnerable regions to climate variability and change (UNFCCC 2007) due to a lack of financial, institutional and technological capacity to respond to climate change impacts (Boko *et al.* 2007). In this regard, the fight against climate change has become one of the greatest global challenges demanding cooperation and participation of both private and public sectors. International efforts to tackle climate change led to the Paris Climate Summit (2015) where actions to stop deforestation and forest degradation were agreed and have become part of high level domestic political agendas of many countries.

The critical role of forests in climate change mitigation and adaptation is therefore widely recognized due to the significant contribution of forests to climate change amelioration through their carbon sink and carbon storage functions. In addition to regulating climate, forests provide a number of important local services that can reduce vulnerabilities and enhance adaptation of people and ecosystems. The forest sector can therefore play a major role in climate change mitigation and adaptation strategies by building resilience to climate change impacts. The achievement of that goal requires practical policy commitments where finance has a pivotal role to play in supporting efforts to reduce emissions, creating green economies and to adapting to the impacts of climate change (Nakhooda *et al*. 2014). In this regard forests have become important when making considerations of how the United Nations Framework Convention on Climate Change (UNFCCC) process can create an enabling environment for harnessing private sector resources for adaptation and mitigation. The achievement of sound adaptation and mitigation goals requires financial support, particularly for developing countries who require technology development and transfer as well as capacity building to effectively respond to the challenges of climate change and climate variability.

However, over the period 1990–2015, the global forest area decreased by 3% from 4,128 million ha to 3,999 million ha in 2015, with the highest rates of forest loss occurring in low income countries (Keenan *et al*. 2015). Primary forests decreased by 2.5% (10% in the tropics) whilst global planted forest area increased from 167.5 to 277.9 million hectares with the increase being most rapid in the temperate zones, and regionally in East Asia, followed by Europe, North America, and Southern and Southeast Asia (Morales-Hidalgo *et al*. 2015, Payn *et al*. 2015, FAO 2016a). The global growing stock, annual wood removals, biomass and C-stocks also increased over the same period with forest carbon stocks and growing stock volume decreasing in South America and Africa (Kohl *et al*. 2015). In sustainably managed forests, the amount of carbon that can be released as a result of harvesting is equal to or smaller than the amount taken from the atmosphere, making forests "carbon-neutral" or "carbon sinks".

Ownership of forests can affect the way they are managed and their relevance to climate change. In terms of global forest ownership in 2010, public ownership constituted 76% (2,969 million ha), the private sector had 20% (774 million ha), whilst unknown or unclear ownership occupied 4% (141 million ha). The largest private and public forest areas were located in tropical regions whilst the lowest were in subtropical regions (FAO 2015). The proportion of state owned forests rose to from 82% in 1990 to 85% in 2010 whilst privately owned forests increased from 14% to 18% of the total forest area over the same period (Whiteman *et al*. 2015). Given that private forest owners may have different management objectives and sources of finance, it might be expected that the structure of forest ownership would be related to a number of other activities including climate change mitigation and adaptation. In this regard, the role of both public and private sectors in forestry in the fight against climate variability and climate change cannot be underestimated. The private sector has a role of financing promotion of low-carbon, climate resilient transitions (United Nations 2015).

A forest carbon storage system can be destroyed by deforestation and forest fires that can decrease carbon sequestration capacity. For example, greenhouse gas (GHG) emissions from deforestation and forest degradation between 2011–2015 were lower (1.8 Gt CO_2/year) (FAO 2015) than the 2005–2010 (6.22 Gt CO_2/year) (Pearson *et al.* 2017) contributing 12–29% of global GHG emissions over that period. During the period 2011–2015, emissions from forest degradation increased to an average of 1.0 Gt CO_2 yr^{-1} compared to an average of 0.4 Gt CO_2 yr^{-1} between 1991 and 2000 whilst emissions from deforestation decreased from 3.9 to 2.9 Gt of CO_2 per year between 2001 and 2015 (FAO 2015).

Following the emergence of climate change related issues, and critical roles of the forestry sector, there is need to collect data on performance of the forestry sector relative to climate change mitigation and adaptation. Given the global evolution of the private forest sector, there is also a need to identify the private sector demands and understand the interactions between the different groups of people and the forest resources as well as their differing needs, privileges, contributions, challenges and priorities, relative to climate change. This study therefore, sought to determine the role of Zimbabwean private and public forestry sectors in response to climate change, as well as the frameworks regulating access to forest and tree based resources in woodlands and savannah, moist forests, plantations and woodlots of Zimbabwe.

METHODOLOGY

Study design

The procedure adopted for the study comprised: preliminary literature searches; design of a questionnaire and a visit to the forest and timber industry actors in three provinces of

Zimbabwe where the forestry sector is most active. The methods used ranged from desk-based reviews, case studies and building from the climate change mitigation and adaptation process. Web-based resources were also used. The study involved collection of qualitative and quantitative data from primary sources through questionnaire and face-to-face interviews with staff working in planning and /or production sectors to obtain information on company profiles and their activities relative to climate change adaptation and mitigation. All data were collected between May, 2016 and July, 2016. The research focused on actors with knowledge of the attitudes and actions of a wide range of private, public and NGO forestry sectors. The qualitative data consisted of information on management and policy analysis related to sustainability and climate change adaptation and mitigation in the private sector, public sector including local governments and NGOs. Quantitative data included data on areas planted and production records. Descriptive insights were sought into the role of the forestry sector in climate change.

Description of study population

The forest types covered included pine, eucalyptus and wattle plantations concentrated in the eastern highlands of Zimbabwe under Boarder Timbers, Allied Timbers, Wattle Company, Mutare Boards and Doors, four small scale mobile millers and five timber based small scale enterprises. Natural forests with hardwood timber for harvesting are mainly within gazetted forests and Rural District Councils (RDCs) in Matabeleland and Midlands provinces. The RDCs forests in this study were Chimanimani involved in exotic plantations and wood based SMEs, Lupane and Gokwe. Non-governmental organisations contacted for comments included Towards Sustainable Use of Resource Organization (TSURO) in Chimanimani, Environment Africa, Southern Alliance for Indigenous Resources (SAFIRE), Sustainable Afforestation Association (SAA), Tobacco Industry Marketing Board (TIMB) and World Vision. The Timber Producers Federation (TPF) is an association of timber producers focusing on interests of the forestry industry in Zimbabwe. TPF membership includes non-forest based industries such as Tanganda Tea Estates and Agricultural Rural Development Authority (ARDA), a government parastatal.

Sampling techniques

Two sampling techniques were used for the study; namely, purposive and simple random sampling. The purposive sampling technique was used to select respondents in the primary and secondary forest industry and NGOs working in natural resource management for questionnaire administration. Both planted and natural forests under state, private or rural district council management were included. A simple random sampling technique was used to select actors in the SME industry. A total of 21 organisations were selected for the study; eight in primary production, six in secondary production, eighteen SMEs and seven NGOs working in natural resource management. Individuals in the planning or production divisions participated in the study whilst for NGOs, the ecologists/ environmentalists gave information on organisational activities. A case study approach was used for six wood-based enterprises in Bindura market.

Primary and secondary data collections

Information to enable the mapping out the key actors in primary and secondary forest production in Zimbabwe including small and medium scales of operation engaged in climate change related activities were obtained from annual reports from the Forestry Commission, Timber Producers federation, EMA and NGOs working on natural resource management. Insights about their perspectives were obtained from direct face-to-face interviews and questionnaires administered via email with individual follow up interviews. The research questionnaire was designed with seven sections based on the research objectives and questions. The sections of the questionnaire included types or category of forest activities and the roles by gender, areas covered (ha), activities related to climate change mitigation and adaptation, sustainability of raw materials, production targets and business performance, forest carbon emission and sequestration potential plus marketing and trade in forest carbon, knowledge about laws and regulations governing activities in forestry by key actors and best practices for SME engagement in trade of forest carbon. The questionnaire also gave an opportunity for information on perspectives about the future including possibilities to trade in forest carbon. Some of the information was collected from annual reports by the Timber Producers Federation and Forestry Commission for the period 2009–2015. Information relating to the legal frame work / for forestry sector included the Forest Act (Chapter 19:05), Communal Land Forest Produce Act (Number 20 of 1987), Environmental Management Act (Chapter 20:27), Statutory Instrument 7 of 2007 (Environmental Management Regulations) and Statutory Instrument 112 of 2001 (Forest Regulations), Statutory Instrument 9 of 1989 and statutory instrument 116 of 2012 (utilisation of forest products). Other information sources were web based. These were used to evaluate frameworks for regulating access to forest and tree-based resources including tenure arrangements and how they might influence activities in forest carbon.

Data analysis and reporting

Descriptive statistics were used to analyse data collected for the study using SPSS version 21 and Microsoft Excel.

RESULTS AND DISCUSSION

Players in the forestry industry

The key players in the forestry industry in Zimbabwe were categorized into three groups, namely: primary, secondary and tertiary forest production actors. The primary forest production actors were dominated by four big private and two government organisations whereas, the secondary and tertiary

TABLE 1 *Actors of primary forest production in Zimbabwe*

Name	Area (ha)	Forest type	Rotation age (yrs)	Product
Allied Timbers	25,000	Plantation	22 to 25	Logs, poles
Boarder Timbers	27,648	Plantation	Pine 15, 20 & 22 Eucalyptus 6–11	Logs, Poles
Wattle Company	25,445	Plantation	Pine 20–25 Wattle 9–10 Eucalyptus 5–11	Logs, Poles woodfuel
Manica Boards and doors- outgrowers scheme	4,572	Plantations	12–15	Logs
Mutare Board and Paper Mill	3,400	Plantation	12–25	Logs
SAA	>15000	Plantation	7/8	Wood fuel
FC* Matabeleland	821,038	Natural forests	40–60	Fuelwood, Logs, Managing natural forests
FC* Midlands	82,433	Natural Forests	40–60	Fuelwood, Logs, Managing natural forests
Forestry Commission	5,642**	Woodlots	7–10	Fuelwood and poles
TIMB	100	Woodlots	7/8	Fuelwood

FC = Forestry Commission, * Primary processed products from reserved forests mainly in Matabeleland province ** only for 2015 rural afforestation

forest production actors were carried out by small and medium scale enterprises. The major activities carried out by primary forest production actors were: management of natural forests; logging; harvesting of poles; growing of woodlots; management of woodlots; and agroforestry activities (Table 1).

The Forestry Commission manages 18 natural forest management units covering a total of 903,471 ha for hardwood timber in Matabeleland North and one in Midlands provinces. The two provinces have a concentration of hardwood timber species namely: *Pterocarpus angolensis* DC (mukwa); *Bakiaea plurijuga* Harms (teak); *Guibourtia coleosperma* (Benth.) J. Léonard (Mchibi) and *Afzelia quansensis* Welw (mahogany). Compared to the figures shown by Mudekwe (2007), the forest area has reduced by 3% due to illegal settlements and clearing for agriculture.

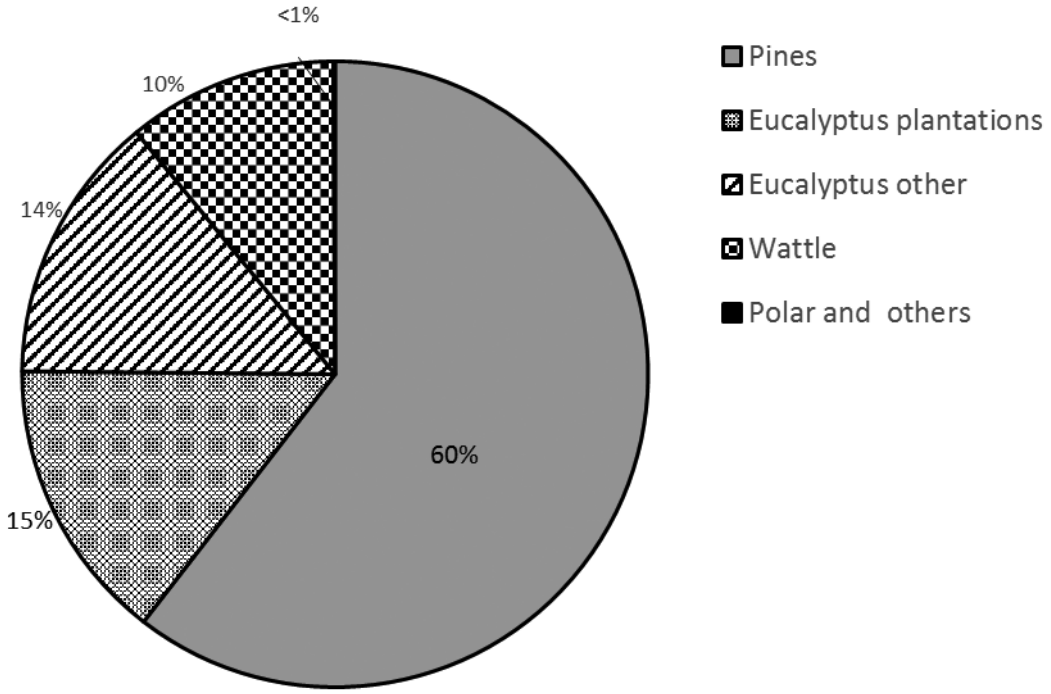
The area under primary forest production ranged from 100 ha to 27,648 ha, resulting to a total of 101,002 ha. Plantations constituted 93.1% of the total area under forest primary production, followed by agro forests (woodlots) at 5.7% and last as natural forests (1.2%). The major tree species for plantations were: *Pinus patula*, *P. elliotii*; *P. taeda*; *P. tecunumanii*; *P. maximinoii*; *Eucalyptus grandis;* and *E. cloeziana* for production of logs, poles and woodfuel. In each of the forest primary production plantations, the rotation age and number of cycles were specified as part of the management plans implemented by respective actors for a given target product.

The plantation estates were mainly located in the eastern highlands except Hunyani (Norton, Marondera, Headlands) and Mtao in Mvuma. There were three main actors possessing above 25,000 ha each, under pine, eucalyptus and wattle species (Figure 1). For instance, Boarder Timbers' owned approximately 28,000 hectares of plantable area, 83% is intended for pine saw log production mainly from the following tree species: *P. patula*; *P. elliotii*; *P. taeda*; *P. tecunumanii*; *P. maximinoii*; *E. grandis*; and *E. cloeziana*. The Wattle Company grows *Acacia mearnsii* (wattle) for tannin and charcoal/firewood production. Several Eucalyptus species are used in the rural afforestation programme (including the tobacco wood energy programme). These activities are carried out to pursue non climate objectives such as soil conservation or sustainable forest production but are important in carbon capture.

The activities implemented by actors to support sustainable forest management under primary forest production included forest protection; fire management; salvage harvesting; vegetation monitoring and selective harvesting in natural forests.

The rural afforestation programme has tree planting targets of over 10 million trees per year and is supported by the tobacco wood energy programme facilitated by the Sustainable Afforestation Association (SAA) (>15,000 ha) and Tobacco Industry Marketing Board (TIMB) (100 ha) for establishing woodlots for tobacco curing energy under partnership with farmers. Some smaller-scale producers exist but have very limited significance in terms of output and influencing broad activities in the forestry industry. The Forestry Commission is responsible for forest extension services including supervision of timber concession operations, safari operations and has sub offices at provincial and district level. A total of 2,676 forestry projects have been registered under the Forestry Commission as forest-based enterprises (FC 2015).

FIGURE 1 *Proportion of area planted under exotic tree species in 2014*



On sawmilling, organisations such as Allied Timbers at some point awarded contracts to about 50 sawmill operators under a payment arrangement where harvested timber was equally shared between the company and the contractor to reduce their burden. In Mutare urban, more than 10 mobile sawmills are a source of livelihood for many people. The mills have no targets as customers normally bring logs for sawing. Each mill has about five employees who are all males. Each lorry load produces about 10 m^3 of sawn timber and these come haphazardly. The small actors are important throughout the country for subsistence, and local trade in a diversity of wood products. They are however, not well-monitored and therefore are difficult to regulate (Molnar *et al*. 2010) as most of them do not have plans or targets, their operations are determined by customer demand.

Rural district councils in the two provinces also allow harvesting of logs by concessionaires under supervision of the Forestry Commission. In 2014, ten concessionaires operated in Matabeleland and two in Midlands but the numbers ranged from 10–13 over the past five years. Some were suspended after failing to pay royalty fees to the Forestry Commission and district councils (Forestry Commission 2012). Concessionaires are actors given the right to exploit timber in state forests with limited concern for the rights or benefits of the people living in and around them. The predominance of concessions in the forest landscapes generated problems with human rights groups because they denied traditional peoples (including indigenous peoples) their customary rights of ownership, access, use, and/or governance of forest lands (Molnar *et al*. 2010).

Other activities include agroforestry activities mainly supervised by the Forestry Commission and some NGOs promoting multipurpose leguminous trees (e.g. *Faidherbia albida)* and fruit trees. The planting of woodlots is mainly led by the Forestry Commission extension services. Agroforestry is now recognized as one of the climate smart agriculture options as communities can obtain diversified products and increased resilience to the effects of climate change (Davis *et al*. 2012, Brandle and Schoeneberger 2014, Van Noordwijk *et al*. 2015).

In small towns and cities, secondary forest production is dominated by small and medium size enterprises (SMEs) often making up 80–90% of enterprises and more than 50% of jobs in forest and wood based employment (Macqueen 2008). Forest based SMEs can be defined as 'business operations aimed at making a profit from forest-linked activity, employing a small number of full-time employees (10–100), or with an annual turnover of US$10,000–US$30 million, or consuming 3,000–20,000 m^3 of round wood annually (Macqueen 2008). In Zimbabwe, the forestry related SMEs do not meet the general criteria for SMEs especially the number of employees which rarely go beyond five. Overall, the SMEs in Zimbabwe are characterised by a diverse range of stakeholders, businesses and structures, with dynamics varying from one province to the other. They operate at local and national scales and are generally excluded from participating in highly competitive commodity-oriented export markets. The local markets are dominated by producers of furniture (81%), firewood (7%), coffins (4%), timber sales (4%) and wild fruits (4%) mainly *Ziziphus mauritiana*. The forest based SMEs in Zimbabwe have created jobs, promoted community development and in a way they have contributed to poverty reduction. The SMEs involved in activities dealing with woodfuel, industrial round wood and poles, operate mostly as merchants. In urban areas, firewood is a common business with each bundle (about 0.04 m^3) costing US$1.00.

Annual firewood production in Zimbabwe is around 9,027,614 tonnes (FAO 2016b).

Other forest related activities include bee keeping that generates some reasonable environmental benefits in addition to cash and honey. Chazovachii *et al*. (2012) and Mazorodze (2015) showed that individuals participating in bee keeping activities had higher incomes than those who did not. In this study, the SME entrepreneurs were not willing to disclose their earnings but only indicated that they were able to sustain their families from their activities. This is probably because there is no proper record keeping and the earnings are used for daily subsistence activities. Asante (2011) reported that 80–90% of SMEs were forestry-based enterprises comprising more than 50% of forestry sector employment in most developing countries, showing their importance in the forestry sector. However, the small and medium sized forest enterprises (SMFEs) often face challenges of inadequate business skills, non-conducive policy environments and limited access to financial services (Tomaselli and Hajjar 2011).

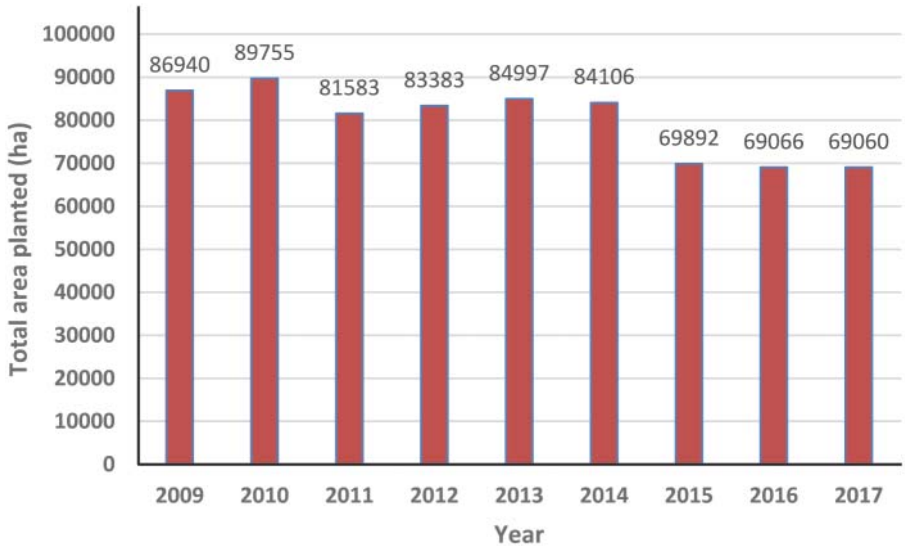
Forests also offer income opportunities for small-scale producers involved in non-timber forest products (NTFPs) activities either as a primary source of income, food or a safety net. The most popular NTFPs are Mopane worms, honey, firewood and fruits such as *Z. mauritiana, Adansonia digitata, Sclerocarya birrea, Uapacca kirkiana, Berchemia discolor* and *Vitex Payos*. Some of the fruits are further processed into jams and oil through the help of NGOs such as Southern Alliance for Indigenous Resources (SAFIRE) and Environment Africa. The NTFPs are not fully quantified, although they play an important role in rural and urban livelihoods. This is common in most developing countries. In this study, NTFPs and other services were considered as secondary or tertiary products together with carbon sequestration as a big product in the face of climate change. The value of commercialised NTFPs was shown by Mabhare *et al.* (2015) as contributing annual household incomes ranging from US$4,120 to US$D10,750 in Muzarabani District of Zimbabwe. *Hyphaene coriaceae* leaves, *Z. mauritiana* fruit and *A. digitata* fruit can contribute 20%, 56% and 24%, of household income respectively. The contribution can be increased with some improvement in market access, value addition, processing, grading and links to finance. Similarly, Tieguhong *et al.* (2012) found that rural communities in Central Africa preferred selected NTFPs for increasing their incomes based on market/economic, social, environmental and technological considerations.

Trends in forest production

The total area planted showed an irregular trend between 2009 and 2014 with the largest area planted in 2010 (Figure 2). Some of the causes in the reduction of the area planted were fire and illegal settlements. Three major tending operations were carried out: weeding done either manually, mechanically or chemically depending on the site conditions to improve tree growth; thinning and pruning were sometimes neglected due to financial constraints although they are known to be important for improving diameter and saw log quality respectively.

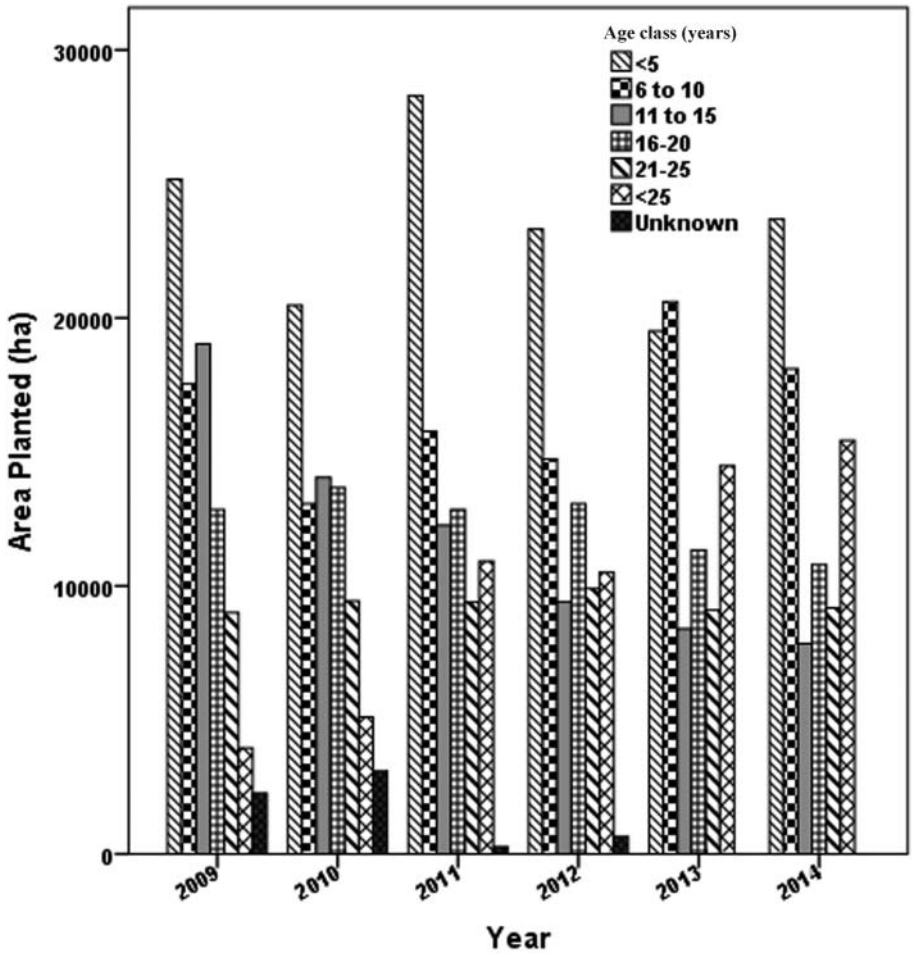
The total area planted under plantations showed larger areas with young trees than old (Figure 3) with the eucalyptus and pines growing beyond 15 years for sawlogs. The greater areas under small age classes suggests some hope for recovery after 10 or more years. There will be a reasonable supply of logs in the future as shown by greater areas planted with less than 10 years as largest areas were <5 years in all years with areas decreasing with age of stand especially 2009 and 2010. From 2011 to 2014 areas >25-year age class were greater due to some delayed harvesting operations in some estates. The distribution of area planted by age class showed that there was a period when replanting was neglected by the forest plantation sector.

FIGURE 2 *Total area under plantation forestry in Zimbabwe between 2009 and 2017*



Source: TPF reports 2009–2017

FIGURE 3 *Total planted areas in plantation forests by age class from 2009 to 2014*



The distribution of areas by age class for each species shows greater areas for lower age classes for pine and eucalyptus, whilst the wattle was lower (Figure 4). All actors in the primary forest production indicated that the volumes extracted were increasing without matching the replanted areas. The rotation cycle for pine is normally 25 years but due to shortage of logs two actors are harvesting timber at 22 and 23 years. Despite this scenario, there is a reasonable supply of raw materials in the future as shown by a greater areas less than 10 years old, especially for pines (Figure 4).

This is boosted by a drive for massive replanting which was once neglected. Allied Timbers has plans of planting 6000 ha/year whilst the Wattle Company plans to reduce their cutting to sustainable levels. The carbon sink function of a forest or plantation increases with the rate of growth and permanence (FAO 2013) starting at a faster rate at initial years and growing at a decreasing rate after 25 years for *Pinus* species (Augustin *et al*. 2007, Mujuru *et al*. 2014). Different species have different mean annual increments varying from 12–40 m^3/ha/yr (Du toit *et al.* 1998, NAS 1980). When plantations are harvested, soil organic carbon stocks and fluxes, are affected including the removal of biomass through harvesting that has long term effects soil carbon formation during decomposition (Covington 1981).

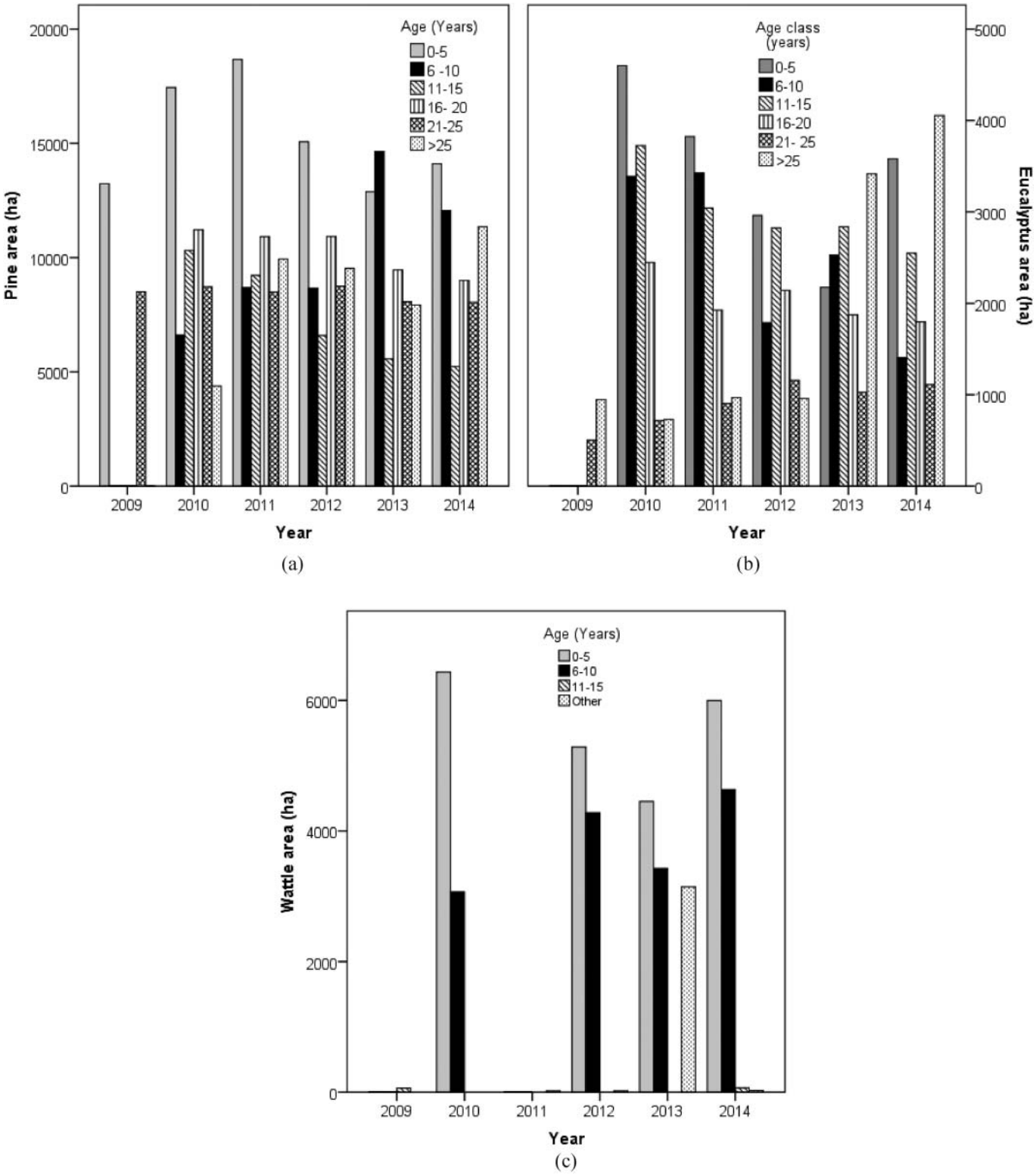
Forest production and processing from 2009–2014 had an average annual production of charcoal at 4,424 m^3, and tannin at 3,217 tonnes (MT) in addition to products shown in Table 2. The annual production of sawmills was highest in 2013 (259,028 m^3) and lowest in 2011 (175,658 m^3). Sawmilling consumed the bulk of the round wood followed by poles, charcoal and firewood.

Wattle bark was extracted for tannin, with the bole used as firewood or charcoal. *Eucalyptus* also provides firewood and charcoal. Over the past five years, round wood processing ranged from 218,202 to 596,058 m^3/year with veneer and plywood showing a decreasing trend whilst particle and fibre board showed an increasing trend between 2009 and 2014. Wattle bark production was almost constant (Table 2). Particle and fibre board industry is boosted by the emergence of markets for melamine boards. The matches producing company and the two pulp and paper companies have closed down. Contract sawmilling contributed 17% of the sawmilling output. The number of operators fell from 59 in 2009 to less than 21 in 2014 mainly due to the economic crisis in the country.

The amount of raw materials required annually ranges from 180,000–250,000 m^3/year and projected future demands are expected to rise even up to 275,000 m^3/year.

In the short term, the raw material availability in plantation forests is threatened by shortages caused by increased harvesting and decreasing resource availability. Climate change impacts can be reduced by developing sustainably

FIGURE 4 *The possibility of future carbon stocks for (a) Pine (b) Eucalyptus and (c) Wattle plantations in Zimbabwe*



managed forests, enhancing sound mobilisation of unused resources, as well as replacing carbon-intensive commodities such as paper, replacing them with paperless communications and utilising wood wastes and bio-fuels to significantly contribute to offsetting GHG emissions. The drive to replant most of the neglected areas would ensure future raw material availability whilst minimising carbon emissions and promoting carbon sequestration in biomass and soils. There are also plans to reduce the energy intensity of production and utilise sawmill wastes by producing of briquettes. Some organisations plan to stop the burning of sawdust and turn it into eco logs whilst others intend to implement finger jointing to

TABLE 2 *Trends in forest production from 2009 to 2014*

Product	2009	2010	2011	2012	2013	2014
Sawn timber (m^3)	194181	150288	175658	184324	259028	228887
Treated poles (m^3)	10279	433718	60791	71011	74293	40073
Veneer & plywood (m^3)	6981	6170	6170	6506	5000	5000
Particle & fibre board (m^3)	6761	5882	7754	8931	8931	8931
Pulp & paper (tons)	10886	0	0	0	0	0
Wattle extract (tons)	2310	3167	3412	3217	2840	
Firewood (tons)	-	-	-	-	11629	10420
Charcoal (tons)	10500	9470	11968	5533	5640	4424
Matches (tons)	1467	0	0	0	0	0

Source: TPF 2009–2014; FAO stats

improve recovery from logs which ranges from 43–53% thus reducing round wood demand, in a way reducing harvesting and deforestation.

Greater global efforts to promote forests and tree growing for carbon sinks as part of the implementation of international climate change related agreements such as CDM and REDD+ may cause future timber supplies to be greater forcing timber prices lower than in the absence of climate change (Sedjo and Sohngen 1998). In Zimbabwe, the TPF offers annual environmental awards to its members as a way of promoting sustainable forest management. Environmental standards and protocols promote emission reduction. Some organisations such as the Wattle Company received Forest Stewardship Council (FSC) certification in 2001 and 2009 in order to ensure sustainability of forest resource base. Most of the forest products conform to the Standards Association of Zimbabwe (SAZ) standard (SAZ -120-2009) and regional standards (SANS 754, BOS 170-2006, KS 516-2008) which are based on international standards. For the products entering the South African market, the South African Bureau of Standards (SABS) is also used. About 25 forest-based enterprises are registered and traded in products conforming to the standards association of Zimbabwe (SAZ). Companies that intend to improve on exports are targeting certification of their products by the Forest Stewardship Council (FSC) and eco labelling.

Climate change related activities in the public sector

The conservation efforts in Zimbabwe have focused on protecting areas of high biodiversity and enhancing the country's nationally determined contribution (NDCs) submitted to the United Nations Framework Convention on Climate Change (UNFCCC). This has created leverage on natural resources to include carbon credits or sales of emission reductions units through international and regional carbon markets and/or carbon pricing mechanisms (NDC 2015). The activities suggested in the NDC enhances forest-based adaptation by reducing forestry sector problems through provision of alternatives for curing tobacco, promotion of timber based forest products and sustainable agroforestry practices.

Government Departments involved in climate change related activities focus on issues of adaptation and building resilient communities. The major players in climate change include the Environment Management Agency (EMA) and Forestry Commission. The EMA is involved in several projects whilst the Forestry Commission is mainly dealing with fire awareness campaigns, afforestation and woodland management. The organizations work in collaboration with NGOs and other government departments. Parks and Wildlife Management Authority, the Ministry of Energy and Power Development and the Ministry of Agriculture carry out conservation of natural wildlife habitats, promote use of alternative energy sources and promoting climate smart agriculture respectively. In gazetted forests, the Forestry Commission conducts fire awareness campaigns, veld fire controls, enrichment planting, establishment of tree nurseries, woodland management for communities and agroforestry.

Furthermore, communities are encouraged to form resource management committees. In rural areas, CAMPFIRE is community based natural resources management (CBNRM) programme developed by the Government of Zimbabwe through the Ministry of Environment, Water and Climate, facilitating CBNRM activities in rural areas. The programme focuses on improvement of rural livelihoods, rural development, the conservation of biodiversity in natural ecosystems of Zimbabwe with supporting projects on hunting, tourism, Mopane worms, beekeeping and crafts. A summary of the activities to support sustainable forest management (SFM) is shown in Table 3.

The Forestry Commission assisted communities to organize resource management committees in 2012 and to formulate sets of bylaws to guard the resource abuse. NGOs are also helping communities to do similar exercises to promote sustainable resource utilization. In other countries such as Canada, sustainable forest management has been achieved through partnerships for shared decision-making which support social, environmental, and economic sustainability in forest management (Hvenegaard *et al*. 2015). The formation of woodland management plans, resource management units and local bylaws is a step in the right direction but there may be need to go further and make some agreements by

TABLE 3 *Activities promoting sustainable forest management in natural forests of Zimbabwe*

ACTIVITY	2011	2012	2013	2014	2015
Fire awareness campaigns	37	74	8	37	422
Early burning (ha)	46100	137553	73882	102068	42900
Woodland management plans		13	18	49	41
Resource management units	70	56	30	64	77
Local bylaws (No. of communities)		48	29	57	51
Control of bush encroachment (ha)	501	1.75	0	247	12

government to transfer the tenure and use rights to communities in order to enable them to function and conserve the forest resources (Barrow *et al*. 2016).

Climate change related activities by the private sector and NGOs

About 80% of the private companies in forestry sector activities contributed in one way or another to climate change related activities, but most were limited to ways of reducing emissions in industrial operations and tree growing. In forest plantation estates catchment areas are left with natural vegetation managed as high valued conservation areas. The limited adaptation activities included fire, management aimed at tactically avoiding the occurrence of fire which is indirectly linked to climate variability and climate change. The other adaptation strategies were linked to tree planting, pests and disease management, species diversification, management of invasive species, and community outreach among others. The Zimbabwean forestry sector plans to diversify the species for planting from existing dominance of *P. patula,* currently occupying 90% of the planted area and *E. camaldulensis* covering more than 70% of the trees planted outside plantations, to enhance the sector's adaptive capacity. This is in line with a study carried out in Belgium by Sousa-Silva *et al.* (2016) showed that 96% of forest owners adapted by promoting mixed species whereas 92% opted for selection of species better adapted to climate change. Other species planted in this study included exotic fruits, indigenous trees, and *Jatropha* spp (Forestry Commission 2015).

However, there is need for businesses to adapt and build adaptive capacity in the societies where they operate. In most cases, vulnerability to climate change depends on social, physical and economic factors and most of them are difficult for the private sector to influence alone. There are several forest related adaptation strategies being implemented for selected climate change impacts (Table 4) but the principal challenge facing adaptation projects in Zimbabwe is the uncertainty associated with climatic variability and lack of knowledge on how to adapt. Similarly, in Sweden, some private forest owners did not adapt due to lack of knowledge on how to adapt (Blennow 2012) or they were not sure about what to do about climate change (Furness and Nelson 2012). The private sector is also increasingly aware of climate change risks and striving to alleviate the negative impacts of climate change by maximising the potential opportunities through low carbon economic growth.

In Zimbabwe, NGOs and the United Nations (UN) agencies (UNDP and FAO) are working on several climate change related activities. NGOs such as SAFIRE, towards sustainable use of resource organization (TSURO), World Vision and Environment Africa are more active in forest-related climate change activities than the forestry private sector and SMEs. For instance, SAFIRE facilitated vulnerability assessment and development of local community-based adaptation plans and tree planting /reforestation. The other emerging players in the forest industry include efforts by NGOs and other parties such as, Sustainable Afforestation Association (SAA) and Tobacco Industry Marketing Board (TIMB) who promote the tobacco wood energy programme (TWEP) which compels each tobacco farmer to grow its own tobacco curing trees for its energy source. The SAA is entering into farm lease arrangements with farmers and local authorities to establish plantation woodlots for tobacco wood energy where they will harvest at 7/8 years and two harvests thereafter (before returning the land to the farmer).

Other organisations such as the Friends of the Environment (FOTE) are non-forestry private enterprises who are contributing to climate change mitigation through tree planting activities. They have re-established 14 tree nurseries around the country. The FOTE players who promoted seedling production by resuscitating rural forestry nurseries since 2011 include OK Zimbabwe (5), Nyaradzo funeral services (3), Zimplasts (2), Old Mutual (1), Mimosa (1), Kingdom Bank (1) and Standard Chartered Bank (1). The FOTE had also supported the walkathon event – walking for the trees, which is held annually at the beginning of the tree planting season. A total of 42,624 trees were planted during the walk from 2012 to 2014. Another, organisation TSURO Trust established in 2000, located in Chimanimani District, supports small holder farmers in natural resources management and strengthens their capacity in the production, value addition and marketing of healthy agricultural produce. They also implemented projects that promoted sustainable land and livestock management practices as Holistic Land and Livestock Management (HLLM) and sustainable watershed management. In South Africa, fire management and climate resilient tree selection and breeding are some of the targeted adaptive strategies for the forestry sector (Department of Environmental Affairs 2013).

TABLE 4 *Forest related adaptation strategies for selected climate change impacts*

Climate change impact	Adaptation strategy
Increased risk of fire due to higher frequency of heat waves and expansion of areas affected by drought.	• Forest fire protection – fire guards, fire awareness etc. • Reduce deforestation and degradation which open up the forest lowering shade and humidity, exacerbating local climate variation, and increasing drought, desertification, and susceptibility to fires.
Erratic rainfall	• Protection of land from flooding and erosion • Rainwater harvesting techniques • Use of hydrogel at planting in dry season
Extreme weather events e.g. droughts/ floods	• Tree Planting, Watershed management, Advance warning system, Risk management plans.
Regulation of water flow and water quality	• Protection of stream banks and catchment areas to improve water quality and quantity. • Forest ecosystems store water; regulate base flows; mitigate floods; and reduce runoff, erosion, and sedimentation.
Reduced agricultural yields	• Sustainable forest management as the rural poor increases their collection of wild foods and other products from the forest.
Outbreaks of pests and diseases	• Selection of resistant species

There are several international agencies (including FAO and UNDP), research organizations, and a few private organizations engaged in adaptation and mitigation activities using various approaches including community-based adaptation (CBA). In 2012, Environment Africa launched a project "every child a tree" to promote tree growing at the early stages of life, in addition to other woodland management projects for bee keeping. The World Wide Fund for Nature (WWF) also has projects for promoting a forest-based incentive system through bee keeping and reducing the tobacco production footprint through promoting efficient tobacco curing technologies. World Vision is embarking on community activities related to natural resource management including training on watershed management and disaster management.

Mitigation activities include initiation of farmer managed regeneration projects, watershed management and planting of indigenous trees such as the *Syzygium* species (0.5 ha) and *Jatropha.* They have also embarked on flood management and water conservation using the food for asset concept. The SAA assists farmers to form fire brigades and cluster fire committees with 10 or more farmers. The organization supports farmers by providing funding for meetings. The Wattle Company supports 'TEAM Vumba', a community based environmental project for clearing exotic species from the Vumba area. The Forestry Commission also works with communities throughout the country assisting farmers to form resource management committees, woodland management plans and formulating associated Bylaws. A summary of the forest related adaptation strategies for selected climate change impacts is shown in Table 4. The forestry sector and downstream industry are mainly on a small scale, involving family members, communities, small forest owners and local enterprises.

The forestry sector also conducts some climate change related strategies including awareness, forest enhancement and biomass/carbon assessments in natural forests. Furthermore, forest conservation is promoted through livelihood activities such as bee keeping and NTFPs sustainable harvesting. The activities are supported by improved forest governance through gender integration and by-law formulation and application whilst natural forest patches in forest plantations, are protected as high valued conservation areas in communal lands.

Climate change mitigation activities by the forestry sector include reducing emissions from deforestation and forest degradation, enhancing forest carbon sinks and product substitution to limit greenhouse gas emissions. Key forest sector mitigation actions include reducing deforestation and forest degradation, fire management, afforestation/reforestation and sustainable forest management in all sectors (Table 5). Similarly, in the UK, forest sector activities are reported to be more focused on mitigation but some adaptation activities including promoting diversification of species choice and changing silvicultural systems are undertaken (Buizer and Lawrence 2013). In Zimbabwe, the scenario is the same with priority given to adaptation than mitigation (Government of Zimbabwe 2015). Reduction of deforestation, afforestation and reforestation will result in improved carbon sequestration.

In Zimbabwe, although, the public sector has more ability to take the risk in forestry projects, the NGOs are leading the way by experimenting and demonstrating adaptation. The private sector however, is also faced with risks associated with climate change (droughts and floods), fire, pests and diseases and illegal settlers. They however, do not know how to design effectively mitigate and adapt to climate change. Uncertainty is mainly about the success of alternative species to resist drought, pests and diseases. Other uncertainties are in the market conditions for carbon as there may be a shift in global funding mechanisms and impacts of projected carbon prices, different perceptions of climate risks, competing values, lack of key adaptation specialists and supporters plus inadequate tools to monitor effectiveness of the adaptation efforts. In this regard, adaptation activities can be affected by other factors such as lack of adequate research, monitoring

TABLE 5 *Key forest sector mitigation actions*

Activity	Mitigation Action	Examples	Carbon Benefits
Reducing deforestation	• Managing Natural forests • Fire prevention • Fire awareness	• Prevent forest loss • Law enforcement • Better forest management	• Maintain CO_2 removals
Use of wood energy for tobacco	• Use of Rocket Ban for curing tobacco • TWEP promotion	• Use of Solar energy • Use of methane • Tree planting for tobacco	• Substitution of fossil fuels
Afforestation/ Reforestation	• Expansion of planted area	• Rehabilitate degraded lands • Enrichment planting	• CO_2 removals
Sustainable forest management	• Maintain/increase forest Carbon stocks • Policy support • Good forest governance	• Restore degraded areas • Species selection for pest and disease resistance • Reduced impact logging	• CO_2 removals

and funding. Underestimating the complexity of adaptation as a social process can create unrealistic expectations about achieving intended adaptation outcomes (IPCC 2014).

As in other developing countries, the ability of the forestry sector in Zimbabwe to participate in carbon markets is severely constrained by Kyoto Protocol rules that apply only to afforestation and reforestation projects. The emergence of REDD+ opened a new way for developing countries to participate in carbon trading. In this study, no organisations were participating in marketing and trade of forest carbon although two projects have designed some REDD+ projects whose carbon has not been traded. The biggest is the Kariba REDD+ project managed by the carbon Green Africa covering three rural district councils extending over two provinces. Through the Kariba project, farmers are taught skills to sustainably increase the productivity of the land and marketing to increase distribution and income from crops which in turn would prevent future clearing. The project establishes community nutrition gardens where farmers apply productive land methods to secure health, employment and income generation. Furthermore, community members are supported in beekeeping and to set up their own sustainable businesses aligned with conservation goals.

Other rural district councils, such as Mutasa and Chimanimani districts are working on potential REDD projects with the assistance of some private companies. Involvement in marketing and trade in forest carbon is limited to both the government and the private sector as they await the outcome of the existing REDD+ project in Kariba. NGOs such as World Vision, SAFIRE, Environment Africa, WWF and TSURO trust are working on projects that could qualify for future carbon trading. Furthermore, there is inadequate funding for effective climate change adaptation and mitigation. Funding from both the public and private sectors is critical for sustainable forest management. However, financial resources are currently insufficient and relatively small compared to the needs (Barnard *et al*. 2014). NGOs have intermediary roles and help communities to acquire and understand climate issues taking into consideration the two important points stressed by the UNDP (2015), i.e. (i) environmental management becomes effective as a function of inter-sectoral collaboration, strategic partnership with regional and global actors, with consultative horizontal activities comprising communities and traditional leaders, and (ii) that addressing poverty through inclusive and equitable economic growth because it is the major driver of environmental degradation.

CONCLUSION AND RECOMMENDATIONS

Results suggest that there is no consistent pattern of forest management in response to climate change by the state or private forest organizations without some reasonable effort from NGOs. There is, however, a realization of climate change and some effort to change management practices, although with a lot of uncertainty about how to adapt. It was evident from the study that among the key actors the level of climate change adaptation is very low and somehow difficult to measure, and in cases where some adaptive actions are taking place they are not normally the consequence of climate change.

In order to improve private sector participation in climate change actions, the following are recommended:

- There is a need for serious engagement and education on how to adapt to the effects of climate change. Best practices to engage the private sector in climate change adaptation and mitigation need support from approaches, policies and practices that would effectively integrate the objectives of climate change mitigation and adaptation with biodiversity conservation and sustainable forest management (SFM) while contributing to the welfare of rural people.
- All actors in the forestry sector need to be empowered so that they are able to monitor GHG emissions in order to make appropriate decisions.
- Silvicultural and nursery practices may need to be adapted in light of climate change challenges.

- The effectiveness of the private sector in climate change activities depends on the degree to which the climate benefits are aligned and the political support for activities. Therefore, carbon trade and carbon prices can stimulate higher emission reduction targets.
- The private forestry sector has greater capacity to contribute to local and global climate change adaptation and mitigation given well-tailored policy and financing mechanisms to motivate them undertake desired operations.

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The role of the Kenyan private forestry sector in response to climate change mitigation and adaptation

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SUMMARY

The impacts of climate change and variability are evident across all sectors of the economy in Kenya, including forestry which is crucial to sustainable development. In this regard public and private sectors have developed programmes addressing climate change mitigation and adaptation. However, little has been documented on the role of the Kenyan private forestry sector in response to climate change. This study sought to identify key actors in primary and secondary forest production engaged in climate change, and evaluate the state of smallholders and the small- and medium-scale private sector in the forestry carbon trade. Cross-sectional surveys and purposive selection of key informants were used to collect data. Some of the players in the forestry sector that are consciously engaged in climate change activities included farmers, and aviation and manufacturing industries (such as Kenya Airways, British American Tobacco (BAT) and Bamburi Cement Company, that support tree planting to offset their carbon emissions. Wildlife Works (WW) and The International Small Group Tree Planting Programme (TIST) are currently engaged in the forestry carbon trade. It was found that engagement of the private forestry sector in climate change activities in Kenya is still in its infancy and therefore institutional, technical, capacity and financial support is required to unlock the potential.

Keywords: private forestry, forest production, climate change, carbon trade, practices

Rôle du secteur forestier privé du Kenya en réponse à l'atténuation et à l'adaptation au changement climatique

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Les impacts du changement et de la variabilité climatiques sont évidents dans tous les secteurs de l'économie Kenyane, y compris la foresterie qui est essentielle au développement durable. À cet égard, les secteurs public et privé s'y sont engagés dans des programmes d'atténuation et d'adaptation aux changements climatiques. Cependant, très peu d'information existe sur le rôle du secteur privé forestier du Kenya en réponse au changement climatique. Cette étude visait à identifier les acteurs clés de la production forestière primaire et secondaire impliqués dans les programmes de changement climatique et à évaluer la situation des petits exploitants ainsi que des petites et moyennes entreprises privées dans le marché du carbone forestier. Les données ont été collectées auprès des informateurs clés sélectionnés de façon raisonnée à travers des enquêtes croisées. Parmi les acteurs délibérément engagés dans les programmes de carbone forestier associés au changement climatique, on compte des agriculteurs, des industries manufacturières et de l'aviation (telles que Kenya Airways, British American Tobacco (BAT) et Bamburi Cement Company) qui soutiennent la plantation d'arbres afin de compenser leurs émissions de carbone. Certains autres acteurs tels que *World Life Works* (WW: Travaux Mondiaux de Vie) et *International Small Group Tree Planting Programme* (Programme international pour des petits groupes de planteurs d'arbres (TIST) se livrent actuellement au commerce du carbone forestier. Il a été constaté qu'au Kenya, l'engagement du secteur privé dans les activités forestières visant à atténuer les effets du changement climatique en est encore à ses balbutiements et qu'un soutien institutionnel, technique, financier ainsi qu'un développement des capacités serait nécessaire pour mieux révéler le potentiel dans ce domaine.

El papel del sector forestal privado de Kenya en la respuesta a la mitigación y adaptación al cambio climático

D.L. MAKANJI y V.O. OEBA

Los impactos del cambio y la variabilidad del clima son evidentes en todos los sectores de la economía de Kenya, incluida la silvicultura, que es crucial para el desarrollo sostenible. A este respecto, los sectores público y privado han elaborado programas de mitigación y adaptación al cambio climático. Sin embargo, se ha documentado poco el papel del sector forestal privado de Kenya en la respuesta al cambio climático. Este estudio buscó identificar a los actores clave en la producción forestal primaria y secundaria involucrados en la respuesta al cambio climático, y

evaluar el estado de los pequeños propietarios y del sector privado de pequeña y mediana escala en el comercio de carbono forestal. Se utilizó una encuesta transversal y una selección intencional de informantes clave para recopilar los datos. Algunos de los actores del sector forestal involucrados conscientemente en acciones de respuesta al cambio climático son los agricultores, la aviación y las industrias manufactureras, como Kenya Airways, British American Tobacco (BAT) y Bamburi Cement Company, que apoya la plantación de árboles para compensar sus emisiones de carbono. Worldlife Works (WW) y el Programa Internacional de Plantación de Árboles en Grupos Pequeños están involucrados actualmente en el comercio de carbono forestal. En conclusión, la participación del sector forestal privado en la respuesta al cambio climático en Kenya es todavía incipiente y, por lo tanto, se necesita apoyo institucional, técnico, de capacidad y financiero para liberar el potencial.

INTRODUCTION

Climate change affects all nations and according to UNEP (2017), no continent will be affected as severely by the impacts of climate change as Africa. Given its geographical position, the continent will be particularly vulnerable due to its considerably limited adaptive capacity, and exacerbated by widespread poverty due to a rapidly expanding population not commensurate with socio-economic transformation. Raid and Toffel (2009) noted that the challenges associated with climate change will require governments, citizens, and firms to work collaboratively to reduce greenhouse gas emissions, a task that requires information on companies' carbon risks, opportunities, strategies and emission levels.

Minang *et al.* (2015) note that landscapes are areas where various actors interact with the environment and among themselves. From a forestry perspective, the actors will include firms and individuals that are actively involved in private sector activities hinged on forestry. Firms that rely on natural resources for economic activities are interspersed with rural communities in areas where they operate. To manage these landscapes sustainably means that operations of all players in the landscape in relation to climate change must be understood. Forestry related firms in these landscapes are directly or indirectly affected by climate. Understanding their response is vital because they may also be playing part in contributing to climate change through their activities.

Kolk and Jonatan (2004) stated that climate change is an international environmental issue that has increasingly attracted business attention and poses strategic dilemmas for companies across a range of industries. It is possible to have a private sector that operates across borders, under a different socio-political climate but their impacts in terms of climate will be similar as climate and climate change does not respect artificial borders. Further, it must be noted that countries are currently involved in multilateral environment agreements that they must respect. This means that forests in one country are likely to be subjected to the same environment regime as the neighbours.

Berkhout *et al.* (2006) notes that organisations, such as business firms (primary to tertiary producers in the case of forestry), are the primary socio-economic units within which processes of adaptation will take place, even if their vulnerability and adaptive capacity will be profoundly influenced by the market and regulatory contexts within which they operate. If markets demand that firms behave in a certain way, for example through the polluter pays principle, then it likely that firms will comply or perish. Regulation is also another way in which firms may be forced to adapt to a changing environment. Regulation may be either internally imposed through industry associations or they may be through local or central government regulation. Either way, firms will have to respond to the needs of the regulations.

According to Mendelsohn (2000), firms and individuals will likely engage in substantial private adaptation with respect to climate change in such sectors as farming, energy, timber and recreation because it is in their interest to do so. Ruddell *et al.* (2006), notes that forest carbon projects offer a practical and credible low-cost option to mitigate CO_2 emissions. Pattberg (2010), notes that public–private partnerships typically build on a voluntary agreement between actors from various sectors- governments, industry, activists, scientists, or international organizations – to achieve a specific sustainability goal; in other words to govern a distinct issue area. It is thus indeed hard to work in isolation in the case of climate related issues. One sector may play a vital role in propping up the other sector to play its rightful role in climate change related matters. The role of the international community cannot be gainsaid given the nature of cross-border environmental issues.

This study focused on the role of the private forestry sector in Kenya with a view to contributing to a better understanding of the key actors, their activities and an understanding of the opportunities that exist which would contribute to adaptation and mitigation of the effects of climate change.

METHODOLOGY

A cross-sectional survey was used in this study to gather qualitative and quantitative data. Purposive sampling was used for the study based on an understanding of the forestry sector in Kenya. Primary data were collected by using a semi structured questionnaire and observation schedule. Primary data involved inquiries into climate adaptation and mitigation activities in which the interviewee is involved. Personal interviews were held and group discussions in two sites in Meru County. In both cases, key informants played an important role in the identification of potential interviewees. In the case of secondary data, which involved collection of written works and activities of the identified players this was provided by key informants where it was available or through desk reviews. The respondents were drawn from Nakuru, Nairobi, Embu, Meru, Nyeri, Laikipia, Mombasa, Kwale, Eldoret, Trans Nzoia, Kakamega and Kericho counties. The final list of information sources and categorization is as indicated in Table 1 below.

TABLE 1 *Categorization of data sources*

Category	Number interviewed	Business Type
Kenya Forestry Service	6	Parastatal
Saw Millers	10	Private
Kenya Forestry Growers Association	1	Private
Kenya Association of Manufacturers and Kenya Private Sector Alliance	1	Private with more than 2000 members
The International Small Group Tree Planting Program	3	Private
Farmers	45	Private
Wildlife Works	1	Private
Bamburi Cement (Lafarge Ecosystems Diani Estate)	1	Private
Kenya Marine and Fisheries Research Institute	3	Parastatal
VI Agroforestry	1	Private
TOTAL	72	

The data were analysed using content analysis approaches since the primary and secondary data were largely qualitative. In this approach, various responses were aggregated together to generate specific themes of focus and discussions in line with the study objectives. Overall, the following themes were created and presented in the results and discussions:

- Key actors in primary and secondary forest production engaged in climate change mitigation and adaptation that included;
  - Saw-millers in forest-based activities;
  - Farmers in forest-based activities;
  - Tea industry in forestry; and
  - Other emerging players in forestry
- Key actors' operations on marketing and trade in forest carbon;
- Key private actors in Kenya pioneered carbon markets and trading; and
- Best practices profiling smallholders and SMEs in markets and trading in forest carbon

RESULTS AND DISCUSSION

Engagement of saw-millers in forest-based activities

The saw-millers/wood processors are mainly situated in Kenya's high potential areas where plantation forestry is carried out in government forests. They varied from large scale, medium and small size investments depending on the installed capacity and types of machinery available for wood processing.

The existence of a few large-scale operators in Kenya and a few of medium size shows a potential for obtaining the skills and knowledge gathered from such large-scale operators in up-scaling the small-sized ones. This may take place if suitable frameworks are established to strengthen public-private partnerships in forestry, private-private partnership in forestry and other modes of engagement to address in a consultative manner the challenges posed to the forestry sector with a view to focusing on promoting climate resilient technologies.

The enterprises involved in timber extraction were mainly secondary producers. Some of them were involved in primary production through the parcels of land that they own which were planted with trees. Notably, none of the millers took part in a very specific way in structured activities in the context of adaptation and mitigation even though their activities indicated a potential to address climate change mitigation and adaptation. This may be closely linked with studies undertaken by Lawrence and Morzano (2014) in North Wales where they found that woodland managers were not generally convinced to respond to climate change, but on were forest health issues such as pests and diseases that they considered a more serious threat than climate change.

Engagement of farmers in forest-based activities

In this study, farmers were considered in three groups, namely; small-scale farmers, farmers engaged in forest use and protection; and commercial forestry farmers. The small-scale farmers are those who are carrying out tree farming activities on their own to meet their domestic and other demands. This group benefits from planting trees for their own use and from the support provided by non-governmental organizations. The involvement of farmers in tree planting as woodlots or boundary planting or agroforestry with the main objective of meeting household needs has the potential of contributing to climate change mitigation and adaptation. The summation of such small scale farmers nationally will have a significant effect on the total tree cover on farmlands at different stages with a different capacity to sequester carbon and also supply timber products to household, whose surplus can generate extra income that might cushion farmers from adverse effects of climate change. The interest taken up by farmers in primary forest production needs to be advanced in a way that it can effectively address the challenges brought by climate

change and variability, especially to vulnerable groups. One novel approach towards catalysing the role of farmers in tree planting and processing is to graduate them into structured farmers groups and associations in order to yield expected impacts of forest and tree resources in response to climate change and other increasing demands of wood and non-wood forest products. This is well supported by other studies (Lundgren 2015, Oeba and Larwanou 2017, Oeba *et al*. 2019) which demonstrated how forest and tree resources are contributing to the enhancement of resilience to climate change among vulnerable groups in Africa and the rest of the developing world.

The study revealed that the forest user and protector farmers operate under Community Forestry Associations (CFAs). These are groups organized by the Kenya Forest Service (KFS), trained for sharing responsibility of sustainable use and management of public forests with designated government agencies. They also carry out tree planting activities in their privately-owned pieces of land. It is important to note that this category of farmers live adjacent to forests and have in one way or another contributed to increasing tree-planting activities in selected forest areas. They have also enhanced forest protection and improved restoration of degraded lands and forests. The motivation of their participation in forest and tree resource management is based on factors such as: direct benefits they derive from use of forest resources for wood and non-wood products; employment opportunities, engagement in seedling production for sale, and farming activities under the framework of Plantation Establishment and Livelihood Improvement Scheme (PELIS), initially known as the *Shamba System*. Studies (Matiku *et al*. 2013) have shown that communities which live adjacent to forests and practice participatory forest management (PFM) derive more benefits as compared to those that are not engaged in PFM. This is because, PFM provides a good arrangement where both parties (stakeholders in forestry) agree to sustainably use forest resources including engagement in non-forest alternative sources of income. Some of the key benefits they derive from forests due to PFM arrangements include, but are not limited to, firewood, herbal medicine, building materials, non-timber forest products and employment opportunities. Recent statistics (KEFRI 2014) have also shown that since the commencement of PELIS in 2007, covering 24 forest stations in Mau, North Rift, Central and Eastern Conservancies, it has increased the forest area under plantations from 2933 ha in 2011 to 9939.6 ha in 2013, with a high rate (>75%) of seedling survival. The period farmers are engaged in agricultural production under PELIS is between three to four years before the tree canopy closes. Studies (Agevi *et al*. 2016, Gichuru 2015) have shown that during this period, farmers are able to derive significant returns resulting in improvement of household wellbeing and sustainable forest management. Whereas no specific outputs have been reported on their contribution to climate change mitigation and adaptation, it is evident that the interventions undertaken by these groups of farmers directly contribute to mitigation and adaptation efforts in Kenya.

The small, medium, and large-scale commercial tree farmers are members of the Kenya Forest Growers Association (KFGA). These farmers grow trees specifically for commercial purposes as all of them are beyond the subsistence fuelwood level. This group is private but works closely with government in some areas. For example, in the Rift Valley and areas around Uasin Gishu and Trans Nzoia, farmers have been collaborating with KFS to plant improved eucalyptus species under the Tree Biotechnology Programme Trust. According to the local KFS officers in Eldoret, over 37 large-scale farmers were involved in this programme. Many of them have planted hundreds and even thousands of hectares of Eucalyptus. These farmers are thus both primary and secondary producers of forest products but have no direct initiatives in climate change activities.

However, their engagement in tree planting increases carbon stocks in forest plantations. The expected returns from tree planting will increase income to the tree growers, which can enable them to strengthen their coping mechanisms against climate change. This demonstrates some knowledge gaps that need to be addressed in order to have a broad based approach towards climate change issues. Some of the good initiatives will involve raising awareness to these groups on the impacts of climate change and projected scenarios in the future, and how the forestry sector can address them such that they can tap into emerging opportunities at regional and global levels.

Engagement of tea industry in forestry

The tea industry plays an important role in Kenya's forestry sector. In Kenya, Finlays and Unilever are some of the oldest and largest tea companies. Finlays has over 1 000 ha of indigenous forests and over 2 000 ha of eucalyptus. The company harvests about 30 ha of trees annually for use under its carbon neutral programme from its plantation estate. Unilever has about 8 250 ha of tea, 1 400 ha of indigenous forest and 1 800 ha of eucalyptus trees. Operating under the Trees4Ever programme, the company aims to be carbon neutral in its activities. It works not only on its estate but also extends its forestry activities to farmers and other players collaborating with it. On its forest estate, the main species planted is *Eucalyptus grandis*. The other species are *Eucalyptus saligna* and *Eucalyptus paniculata*. The company operates under a carbon neutral programme based on its planting and extraction programme.

In this regard, these two multinational tea companies in Kenya are consciously moving towards climate resilient activities through promotion of forestry in different ways. Finlay, for example, indicated that soon it would be involved in carbon markets and trading.

The tea sector in Kenya has undertaken a comprehensive analysis on the impacts of climate change and has recognised that tackling climate change requires a multi-stakeholders' approach (FAO 2015). It is this context that companies such as James Finlay and Unilever, among others, are integrating tree growing in the tea sector, to not only supply biomass

energy but also offset the GHG emission from tea processing and transportation. This way, they will strive to remain carbon neutral by promoting forest conservation and accelerating commercial forestry with the potential of enhanced carbon sequestration.

Emerging players in forestry

The key emerging players in Kenya working towards engaging in forestry to address the effects of climate change include Kenya Airways, British American Tobacco (BAT), Bamburi Cement Company, KEPSA, KAM, and the International Centre for Insect Physiology and Ecology (ICIPE) silkworms on mulberry. These actors play different roles in profiling the forestry sectors' response to climate change. Kenya Airways, for example, launched its Carbon Offset Programme that offers customers the opportunity to offset the CO_2 emissions related to their flights (Kenya Airways 2016). The programme has been developed in cooperation with the International Air Transport Association-IATA. Kenya Airways collects carbon-offset contributions on behalf of passengers to be invested in high quality environmental projects that were identified to have a socio-economic impact and reduce carbon emission in developing countries. Kenya Airways, through IATA will use the funds collected from the contribution by its customers to the Voluntary Carbon Offset Programme to support the Kasigau project that is run by the WW.

BAT-Kenya is working on a programme to reduce the use of wood used in curing. Through the energy-efficiency audit performed by Centre for Energy Efficiency and Conservation (CEEC) in 2009 and repeated every consecutive year thereafter, BAT has achieved a total energy reduction of 25% in the first two years. Consequently, it is benefiting from improved production efficiencies, financial savings and competitiveness, in addition to reducing carbon emissions (CEEC 2013). The company is also exploring collaborating with Migori County to carry out hilltop afforestation programmes that will enhance forest cover in Kenya and increase forest carbon stock in line with Nationally Determined Contributions (NDCs).

Bamburi Cement Company is working on a programme for CO_2 reduction and a greening programme. The company in partnership with the World Wide Fund for Nature (WWF) is engaging in conservation activities such as restoration of degraded lands and forests, enhancement of biodiversity, and eco-tourism among other programme activities. For example, the company has rehabilitated over 305 ha of land that was initially used as a quarry. The preferred tree species is *Casuarina equisetifolia*, but there are many other species used in rehabilitation programmes of degraded lands. Some of the rehabilitated sites are now being used as an ecotourism centre, resulting in additional revenue to the company and promotion of best restoration strategies and approaches for up-scaling. For instance, students from various learning institutions in and outside Kenya currently use this centre for information dissemination to various stakeholders in forestry and field visits. The successes realised from the restoration of degraded lands has enabled the company to establish over 200 ha of plantations on various farmlands in Ukunda. These activities are in line with global concerted efforts on the enhancement of carbon stock as evident in various studies (Jason *et al*. 2018). Specifically, the authors reported that ecological restoration, especially in western United States of America, must consider competing objectives such as improved wildlife habitat, reduced risk of wildfire and other ecosystem services with the potential of climate change mitigation and adaptation. Overall, forest landscape restoration enhances ecosystem resilience and biodiversity conservation. This reduces social and economic vulnerabilities as well as creating green jobs, thus securing livelihoods to communities and forest dependent people in Africa.

Furthermore, KEPSA and KAM are promoting forestry-based activities addressing climate change through the UN Global Compact Network (Global Carbon Compact 2015). The United Nations Development Programme (UNDP) first launched the Kenya Network of the Global Compact (GCNK) in 2005. It was re-launched in 2007, with leading private businesses through KAM, KEPSA and Federation of Kenya Employers (FKE) playing a pivotal role. KAM is a leading and vibrant business membership organization with over 850 members. The Global Compact Network Kenya's positioning within KAM has seen it tap into KAM's strong membership and catapulted a steady growth of GCNK's membership from an initial 12 to the present 94 providing it with the highest number of business participants and the highest member retention rates in the Africa and Middle East and North Africa (MENA) regions. KAM plays its role through promoting green growth, climate change mitigation work, and renewable energy and energy efficiency.

ICIPE's silkworms mulberry project, intends to increase farmers' earnings in Central Kenya through a programme that involves growing of mulberry for silkworm production. The project is a response to changing climatic conditions whereby farmers have lost crops but can earn a living from silk. This programme may fall somewhere between forestry and agricultural carbon. Currently, there is not much information available on this project as it is in infancy stage.

Selected key actors' operations on markets and trading in forest carbon

In Kenya, few private actors are consciously engaged in forest carbon markets and trading. For example, TIST empowers small groups of subsistence farmers in Kenya, to reverse the devastating effects of deforestation, drought and famine. Since 1999, TIST participants have been identifying local sustainable development goals that include tree planting and sustainable agriculture. TIST provides a structural network of training and communications to small groups that allow them to build on their own internal strengths and develop best practices. Small groups benefit from a new income source – the sale of carbon credits that result from the sequestration of carbon from the atmosphere in the biomass of the trees and soil.

The carbon credits have created a new 'virtual cash crop' for the participants who gain all the direct benefits of growing trees and receive quarterly cash stipends based on the greenhouse gas benefits created by their efforts. The maturing trees and conservation farming are expected to provide additional sustainable benefits that far exceed the carbon payments. These may include improved crop yield, an improved environment, and marketable commodities such as fruits, nuts, and honey. TIST utilizes a high-tech approach to quantify the benefits and report the results in a method which includes Global Positioning System (GPS) and a dynamic 'real time' internet-based database.

Role of key selected private actors in Kenya

WW is the first company to pioneer sale of carbon credits in a voluntary market. The company was found in the late 1990s with a mission to bring market-based solutions to conservation of biological diversity by providing sustainable economic benefits to rural communities so they can live a better life. WW has pioneered practical REDD+ solutions that are acceptable to both rural communities and the marketplace. The Kenya based Kasigau Corridor REDD project is the first ever to be issued with Voluntary Emission Reductions (VERs) for REDD under both the Verified Carbon Standard (VCS) and the Climate Community and Biodiversity Standard (CCB), which are the two most comprehensive carbon accounting standards among projects issuing credits in the voluntary market. The project received significant start-up funding from Banque Nationale de Paris (BNP) Paribas in the form of an option pledge to buy VERs over a 5-year period. The project generates over one million VERs per year, making it also the first mega project under the VCS, and will avoid the emission of over 30,000,000 tonnes of CO_2e over the life of the project.

The Kasigau Corridor REDD project is protecting 200 000 ha (500 000 acres) of dryland forest in southeastern Kenya that forms a corridor between two National Parks, Tsavo East and Tsavo West. This dryland forest is under intense threat from slash and burn agriculture, as the local population expands, but as a result of climate change, agricultural productivity in this already marginal area has decreased significantly with nearly 150 000 rural Kenyans, who are benefitting from the distribution of revenues from the sale of the project's carbon offsets.

The project area has a diversity of mammals (over 50 species of large mammal and more than 20 species of bats), birds (over 300 species) and important populations of International Union for Conservation of Nature (IUCN) Red List species such as Grevy's zebra (*Equus grevyi*), Cheetah (*Acinonyx jubatus*), Lion (*Panthera leo*), as well as over 500 African elephants (*Loxidonta africana*) seasonally. The majority of the project area (86%) is comprised of *Acacia-commiphora* dryland forest, where the dominant species are drought specialists.

There are six key elements to the WW brand of REDD+ that make it a successful model. These are job creation, agricultural intensification, physical protection and monitoring, fuel wood substitution, agroforestry and social benefits. WW provides over 400 jobs to the local community (Figures 1 and 2) and brings the benefits of direct carbon financing to nearly 150 000 people in the surrounding communities.

The other private entity in Kenya engaged in the carbon market and trading is VI Agroforestry. It is supported by the Swedish International Development Cooperation Agency (Sida) since 1983. This organization implements the Kenya Agricultural Carbon Project (KACP) in Bungoma, Kisumu and Siaya Counties from 2009 to date. It works with farmers who are involved in both primary and secondary forestry production. The main activities carried out are agroforestry and sustainable agriculture extension. The total estimated forest area of operation is 16,490 ha since 2009. This organization is also carrying out sustainable land management practices including residue management. It is also involved in natural regeneration to enhance genetic diversity, increasing the number of species planted, developing nursery practices that enhance survival, and operations where thinning is done bearing in mind the need for mixed stand and structural diversity. The practice of agroforestry itself also contributes to climate mitigation activities.

About 24 000 tons of carbon has since been sold since 2010. The quantities of emissions have been reduced since the commencement of the reduction process to about 24 000 tons verified and paid for in 2010 and 2011. The second period of 2012–2014 had been verified but awaits the completion of the process and thereafter, the payment. The trading period was 2010–2017 under voluntary carbon markets. The carbon sequestration potentials and projections depended on tree species and other environmental factors. In this sense, about 1.98 million tons of CO_2 equivalent from 2009–2029 are projected to be realised. Reduction of emissions within this system involves reduction on use of inorganic fertilizers and use of compost as an alternative. Practicing reduced tillage and conservation tillage is also used so that there is a reduced emission from the release of CO_2 stored in the soil. For some time many farmers have used burning of crop residue as a way of land preparation. However, under this programme, training is carried out so that there is reduction and avoidance of burning of crop residue.

Another community led mangrove conservation and restoration project commonly known as *"Mikoko Pamoja"* carried out at Gazi Bay in Coastal Kenya, focuses on the policing of illegal mangrove harvesting, as well as the application of local expertise in mangrove planting. The project is managed by three groups: The Mikoko Pamoja Community Organization (MPCO) consists of representatives of Gazi Bay, specifically Gazi and Makongeni villages; The Mikoko Pamoja Steering Group (MPSG) which provides technical support to the MPCO; and The Association for Coastal Ecosystem Services (ACES), a charity registered in Scotland that is coordinating the project.

The main objective of this project is to channel finance to the protection and restoration of mangrove ecosystems in Kenya through the provision of payment for quantifiable ecosystem services. It aims at increasing the quality and

FIGURE 1 *Wildlife Works Hand Made soap*

FIGURE 2 *Wildlife Works Jojoba oil*

extent of the current forest, maintaining and enhancing carbon sinks. Since its inception in 2011, the project's main activities include restoration of coastal ecosystems, planting and conservation of mangroves. The project is working on over 600 ha of mangroves and on annual basis, about 3,000 tons of carbon are traded. *Sonneratia alba* is the main species for restoration whereas *Rhizophora mucranata* is best for carbon sequest and ration and the project has about 107 ha of natural stands and 10 ha of plantation (Plan Vivo 2016).

In view of the description of various actors in Kenya engaged in carbon markets and trading, the contribution of Kasigau REDD+ project to global emission reduction has been well documented and shared in scientific platforms (Oeba and Larwanou 2015, Bernard and Adkins 2014, Atela 2013). According to these authors, most of the pilot REDD+ projects in Sub-Saharan Africa are being implemented by the private sector. This shows the important role that the private sector in forestry plays in the implementation and investment phases of REDD+ globally to ensure long-term protection of forest assets both in public and private lands for provisioning of essential services, goods and products for sustainable development. The global statistics have shown that since the introduction of voluntary carbon markets in 2005 under the REDD+ scheme and others, the projects under implementation including Kasigau REDD+ in Kenya have reduced, sequestered or avoided over 435.7 $MtCO_2e$ (Hamric and Gallant 2018). This implies that voluntary carbon projects have directly contributed to emission reduction and provided important benefits to the communities and ecosystems where the projects are being implemented. This should be encouraged, and more awareness creation enhanced in order to promote the role of private actors in forestry sector upscaling, climate change mitigation and adaptation options among vulnerable communities and ecosystems.

Best practices to profile smallholders and SME's in markets and trade in forest carbon

The interventions undertaken by selected private actors in forestry in response to climate change are in one way or another contributing to emission reduction. Table 2 provides a summary of actors/organisations and their respective contribution in carbon emission reduction.

All these organizations have shown successes in their activities including profiling small holders and SMEs into marketing and trade in carbon. The key activities that have shown successes include the following:

- Job creation within climate change mitigation activities;
- Agricultural intensification leading to more production on less land;
- Physical protection and monitoring which employs rangers thus ensuring local participation and income for the rangers;
- Fuel wood substitution including sustainable provision of fuelwood;
- Agroforestry leading to sustainable land management and provision of both economic and ecological services;
- Social benefits including social amenities that serve a wider population; and
- Climate resilience through creation of programmes that shelter participants from the vagaries of adverse climate.

This means that there has to be a mix of extension (with an emphasis on climate change adaptation and mitigation), conservation (explaining the need for resource conservation and stakeholder participation), use (encouraging sustainable utilization of natural resources especially trees), and trade (developing ways in which trade in carbon can be easily carried out for income). Most of the small players are by

TABLE 2 *Emissions reduction/sequestration by organizations studied in Kenya based on their records*

Organizations	Estimated ha under project	CO_2 sequestration information
TIST	90	Over 30 years, 409,891 tCO_2e emissions reductions, Phase III targets 0.5 to 3 million tons sequestration
WW	200 000	1 million tCO_2e VER per year, 30 million tCO_2 e over 5 years
VI Agroforestry	16 490	Sold 24 000 tCO_2e, estimated to sequester 1.98 million tCO_2e over 20 years
MPCO	117	Over 20 years, 156,292 tCO_2e emissions reduction.

nature profit oriented and would like to see the benefits not only from selling carbon but also from their conservation efforts. For instance, according to the World Bank (2016), the average person from Kenya generates 1 ton of carbon emissions per year. Each offset account for 1 ton of carbon emissions costs $10. For a population of about 44 million, this means that about 44 million tons of carbon are released each year and would require about US$440 million to offset. However, individual efforts starting from the household, farms, small and medium enterprises can contribute to the offset at a potentially lower cost through practices that are beneficial to man and the environment.

CONCLUSIONS AND RECOMMENDATIONS

Many actors in the forestry sector in Kenya are engaged in both primary and secondary forest production. At the lowest level are individual farmers who of their own volition or through incentives provided by the KFS and other players are involved in planting trees on farm or in some form of participatory forest management. The majority of these farmers grow trees to supply them selves with raw materials for subsistence use such as house construction, firewood or for sale to provide income to their households. It was evident from the discussions with key informants and selected farmers that they did not directly link the growing of trees with climate change mitigation and adaptation even though it is recognised that trees sequester carbon from the atmosphere. This is important information that needs to reach farmers in order to enable them to undertake tree growing programmes for climate change mitigation and adaptation.

In Kenya, there is a current call for the country to reach 10% tree cover by 2022, and farmers are key stakeholders in this engagement. The constitution of Kenya 2010 stipulates that each farm holder should allocate at least 10% of the farm area for tree growing. This call is currently spearheaded by the President and the Ministry of Environment and Forestry. One of the motivating reasons for this clarion call is to enable the country to be food secure because Kenya largely depends on rainfed agriculture. It is also meant to assist the country to meet its international obligations on its commitment to Nationally Determined Contributions (NDCs) according to the Paris Agreement (PA) which Kenya ratified. In this regard, there is potential for Kenyan farmers to shift their tree growing programme to consciously focus on climate change mitigation and adaptation, as in the case of farmers enrolled on TIST.

TIST is one of the unique programmes in Kenya that has consciously engaged farmers to grow trees for climate change mitigation and adaptation. They have primarily focused on the following: increasing biomass and carbon sequestered in project areas, providing a sustainable fuel wood supply for the members; providing a new source of revenue to the members from the sale of carbon credits; providing training in important social and health related subjects; and improving the biodiversity of the area by adding canopy and indigenous trees. They have enrolled over 54,000 farmers in the TIST programme. These types of farmers are knowingly engaged in climate change mitigation activities. To date, TIST has validated and verified Voluntary Carbon Standard (VCS) projects all of which were validated, verified and certified as gold level under the Climate Community and Biodiversity Standard (CCBA). They are currently receiving forest carbon credits and sharing the proceeds with farmers.

The actors in the secondary forest production were charcoal producers, loggers, millers and people involved in extraction of non-timber forest products. There are also artisans and builders who may make the third level of producers. These actors were not in any way knowingly engaged in climate change activities, which may be linked to their major focus on business performances in terms of profit margins without due consideration to environmental sustainability. It was evident that some of their activities, especially for saw millers, loggers and other artisans, are contributing to global emissions – and issue about which they need to be informed in order for them to shift their business operations to become more climate-friendly. This is a potential that needs to be harnessed in order to enable these categories of actors to consciously engage in climate change mitigation and adaptation programmes in Kenya.

The key private small, medium and large-scale organisations/companies that were consciously engaged in climate change mitigation and adaptation included Mikoko Pamoja, VI Agroforestry WW, and aviation and manufacturing industries such as Kenya Airways, Bamburi Cement Company and British American Tobacco (BAT). These organisations are knowingly engaged in tree planting and growing programmes, rehabilitation of degraded lands and forests to increase and enhance carbon stock as a mechanism to offset their emissions. They are also engaged in the promotion of ecological functions of the forests and capacity building to improve resilience and adaptive capacity of vulnerable groups

and farmers. Vi Agroforestry, Mikoko Pamoja and WW are currently trading on carbon credits from their project activities This demonstrates the existing potential of the private sector in forestry to address climate change. It is therefore imperative that these best practices need to be promoted and upscaled among other actors in the forestry sector.

The support to VI Agroforestry, Mikoko Pamoja and WW to carry out their afforestation, reforestation and rehabilitation activities is externally funded and relies on carbon credits that are significantly affected by carbon prices in compliance and voluntary markets. This brings a serious challenge in terms of the sustainability of these projects. It is, therefore, necessary that steps should be taken to ensure that once the projects end, the local partners can sustainably run the programmes. This requires the government in partnership with the private sector in forestry to develop suitable institutional and legal frameworks to support the climate change and adaptation activities in a sustainable manner across its devolved units of governance.

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The role of the private forestry sector in response to climate change in central Africa: the case of Cameroon

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SUMMARY

This paper outlines the role of private forestry sector actors in response to climate change in Cameroon using literature reviews, field consultations and stakeholders' analyses. National policy and institutional frameworks on climate change initiatives linked to forests were analysed. Three local non-governmental organisations in partnership with the private sector and one logging company are actively engaged in climate change-related activities such as sustainable forest management, certification, enrichment planting, afforestation, community tree planting and adoption of improved fish-smoking technologies. Although logging companies are the traditional private sector players in forestry, increasing global concerns about climate change have led to new entrants and emerging prominent players in tackling forestry and climate change-related issues. Overall, the analyses suggest low active participation of the private sector in climate change-related activities in Cameroon. This could be reversed by putting in place the correct institutional arrangements and overhauling strategies to ensure the active participation of several other logging companies in the country. From a business perspective, climate change funding facilities need to engage logging companies in climate change activities including rehabilitating disturbed forest sites such as logging gaps, old logging yards and gantries.

Keywords: atmospheric carbon, climate change adaptation and mitigation, climate change initiatives, timber industries

Rôle du secteur de foresterie privée en réponse au changement climatique en Afrique centrale: le cas du Cameroun

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Cet article met en exergue le rôle des acteurs de la foresterie privée en réponse au changement climatique au Cameroun. Des avis littéraires, des consultations et des analyses de parties prenantes ont été utilisés pour réunir l'information sur laquelle se base le papier. La politique nationale et les cadres institutionnels des initiatives liées aux forêts dans le cadre du changement climatique ont été analysées. Trois organisations non-gouvernementales en partenariat avec le secteur privé et une compagnie de coupe sont activement engagées dans des activités liées au changement climatique, telles que la gestion forestière durable, la certification, la plantation d'enrichissement, le boisement, la plantation communautaire d'arbres et l'adoption de technologies améliorées d'enfumage au poisson. Bien que les compagnies de coupe soient traditionnellement les acteurs privés en foresterie, les soucis croissants qu'engendre le changement climatique à l'échelle globale a conduit de nouveaux postulants et les acteurs proéminents émergeants à s'attaquer au changement climatique et aux questions qui lui sont liées. L'analyse suggère généralement que la participation active du secteur privé dans les activités liées au changement climatique au Cameroun est faible. Cette situation pourrait être renversée par une mise en place d'arrangements institutionnels appropriés et de stratégies de remise en état pour s'assurer de la participation active de plusieurs autres compagnies de coupe de bois dans le pays. Du point de vue des affaires, les facilités de financement de la question du changement climatique doivent engager les compagnies de coupe dans des activités visant à atténuer le changement climatique, comprenant la réhabilitation des sites forestiers perturbés, comme les brèches de coupe, les anciens sites de coupe et les chantiers.

El papel del sector forestal privado en la respuesta al cambio climático en África central: el caso de Camerún

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Este documento describe el papel de los actores del sector forestal privado en respuesta al cambio climático en Camerún. Se utilizaron revisiones de la literatura, consultas sobre el terreno y análisis de las partes interesadas para reunir la información para el artículo. Se analizaron los marcos nacionales de políticas e institucionales sobre las iniciativas relativas al cambio climático vinculadas a los bosques. Tres organizaciones no gubernamentales locales, en asociación con el sector privado y una empresa maderera, participan activamente en actividades relacionadas

con el cambio climático, como la gestión forestal sostenible, la certificación, las plantaciones de enriquecimiento, la forestación, la plantación comunitaria de árboles y la adopción de tecnologías mejoradas de ahumado de pescado. Aunque las empresas madereras son los actores tradicionales del sector privado en el sector forestal, la creciente preocupación mundial por el cambio climático ha dado lugar a nuevos participantes y a nuevos actores prominentes en la lucha contra los problemas relacionados con el cambio climático y la silvicultura. En general, los análisis sugieren una baja participación activa del sector privado en las actividades relacionadas con el cambio climático en Camerún. Esto podría invertirse mediante el establecimiento de acuerdos institucionales adecuados y la revisión de las estrategias para garantizar la participación activa de otras empresas madereras en el país. Desde una perspectiva empresarial, las facilidades de financiación relacionadas con el cambio climático deben involucrar a las empresas madereras en actividades relacionadas con el cambio climático, como la rehabilitación de áreas forestales perturbadas, como claros de árboles debidos a las talas, viejas áreas de acopio y maquinaria.

INTRODUCTION

The Earth's average temperature has risen by 0.85°C over the past century as a result of increased greenhouse gas emissions resulting from human activities. It is projected to rise by more than 1.5°C over the next hundred years if appropriate measures are not taken (AFWC 2016). Small changes in the average temperature of the planet can translate to large and potentially dangerous shifts in climate and weather. Forests currently store about half the global terrestrial organic carbon pool. While forests sequester atmospheric carbon when they grow, deforestation and forest degradation are responsible for around 10 percent of global emissions of greenhouse gases (AFWC 2016).

Climate change is being experienced in various ways in the African region. Temperatures have increased, rains have become irregular, droughts are now occurring more frequently and lasting longer and the risks of losing flora and fauna are greater. In addition, desertification is increasing at an alarming rate, leading to serious food security and livelihood concerns for indigenous peoples and forest-dependent communities. Furthermore, sea level rise is predicted to be 40–63cm by 2100. The coastal nations of west and central Africa (e.g., Senegal, The Gambia, Ghana, Ivory Coast, Togo, Sierra Leone, Nigeria, Cameroon, Gabon, Angola) are already experiencing negative impacts of climate change, including coastal erosion due to sea-level rise (AFWC 2016).

Tropical forests are an extraordinary reservoir of carbon and biodiversity. Generally, forests have four major roles in climate change including: currently contributing about one-sixth of global carbon emissions when cleared, overused or degraded; reacting sensitively to a changing climate, when managed sustainably; producing woodfuels as a benign alternative to fossil fuels; and potentially absorbing about one-tenth of global carbon emissions projected for the first half of this century into their biomass, soils and products (AFF 2011). More specifically, Cameroon's forest ecosystem supplies goods and services for local livelihoods and national development. As climate change will have an undesirable impact on the functioning of the forest ecosystem, the livelihoods of the people that depend on forests will become inevitably vulnerable (GoCam 2013 2016). The Paris Agreement commits to welcome the efforts of all actors geared at responding and addressing climate change. The role of the private forestry sector in climate change mitigation and adaptation is considered relevant and new, not only in the African context but also at the international level. However, the degree and the outcome of the implications vary from one region or country to another. Wherever be the context, it is important to take stock of existing private sector efforts, in order to create room for improvement.

Forests feature prominently in the post 2020 global climate change agreement in terms of mitigation and adaptation. The Agreement encourages Parties to implement avoided deforestation, avoided degradation, conservation, sustainable management of forests and enhancement of forest carbon stocks (REDD+) and joint mitigation and adaptation approaches, while incentivizing non-carbon benefits. It also calls for enhanced action on adaptation (UNFCCC 2015). Forests and woodlands are key components of the environment and provide essential services that are critical to combating land degradation and climate change, as well as to conserving wetlands, coastal areas and freshwater systems (Cervarich *et al*. 2016, Bele *et al*. 2011). Forests are central to both mitigation and adaption strategies, as reflected in their inclusion in a large majority of countries' Nationally Determined Contributions (NDCs) that underpin the post 2020 climate change agreement. In this perspective, it is important to note that much of the practices needed for sustainable forest management (SFM) are equally relevant to climate change adaptation and mitigation but adaptation and/or mitigation objectives must be made more explicit in forest management, within realistic parameters (Vincke 2011, Broadhead *et al*. 2009).

Within a few decades, forests have become the centre of attention in the scope of international challenges in climate change and conservation. Climate change is caused by factors such as biotic processes, variations in solar radiation received by earth, plate tectonics and volcanic eruptions (IPCC 2014 2007). Certain human activities have also been identified as significant causes of recent climate change, often referred to as global warming (AFF 2011). One of the causes of global warming is deforestation that is associated with the clearing of virgin forests, or intentional destruction or removal of trees and other vegetation for agriculture, logging, housing, or firewood use without replanting (reforesting) and without allowing time for the forest to regenerate itself (Misra *et al*. 2015, Tchatchou *et al*. 2015, Patosaari 2007). In recent decades, Cameroon's forests have undergone extensive conversion, with half of the historic forest cover cleared for farms and

settlements. At least 20% of remaining forests are degraded or secondary forests and logging development is rapidly opening the major remaining tracts of primary forest, mostly located in the south-eastern portion of the country (SOF 2015).

The private sector is the part of a country's economic system that is run by individuals and companies, rather than the government, or in which the government imposes relatively few restrictions on businesses (World Bank 2012). The private sector is contributing to deforestation and carbon emissions especially where there has not been any sustainable forest management (Bele *et al*. 2011). However, opportunities exist for the private sector to make contributions to reduce carbon emissions and increase absorption. For example, the REDD+ initiative, clean development mechanism (CDM) projects, voluntary market initiatives; increase in the number of trees (afforestation, reforestation, restoration, agroforestry); enhanced use of tree products; improved energy use efficiency (development and implementation of low carbon emission technologies) (Tieguhong 2016b).

There are several implications and consequences of climate change for African forests and forestry including alteration of ecosystems and landscape, change in species distribution, composition and interaction, and conflict at the human-wildlife-livestock interface (FAO 2012). It has been estimated that Cameroon's forests store between 1.3 and 6.6 gigatonnes of carbon, most of which is locked up in forest vegetation (GoCam 2013). Different activities are associated with the enhancement of forest carbon stocks including reforestation programmes (to sequester carbon) and careful management and protection of remaining primary forests to retain carbon (Boundzanga 2013, Locatelli *et al*. 2008, Kurz 1998). Cameroon contains some of Congo Basin's most biologically diverse and threatened forests. However, in recent decades, Cameroon's forests have undergone extensive conversion, with half of the historic forest cover cleared for farms and settlements (Topa *et al*. 2009). At least 20% of remaining forests is degraded, or may best be described as secondary forests. Agricultural clearing is the primary cause of deforestation with logging by the private sector rapidly opening up the remaining tracts of primary forest located in the southeastern portion of the country (Neba *et al*. 2014).

Based on this understanding, the private sector's engagement in sustainable forest management (SFM) initiatives that aimed at contributing to climate change mitigation and adaptation are responses that are worth examining. Therefore, this paper set to take stock of the response of the forestry private sector to climate change in Cameroon, highlighting the following; (i) the efforts of traditional key private actors in both primary and secondary forestry production; and (ii) the challenges, policy and institutional settings in place to enable appropriate future responses to climate change. The paper draws on lessons from selected pioneer forestry private sector actors in Cameroon to demonstrate how little efforts can deal with the challenges of climate change mitigation and adaptation in their daily business activities.

METHODOLOGY

Study Area

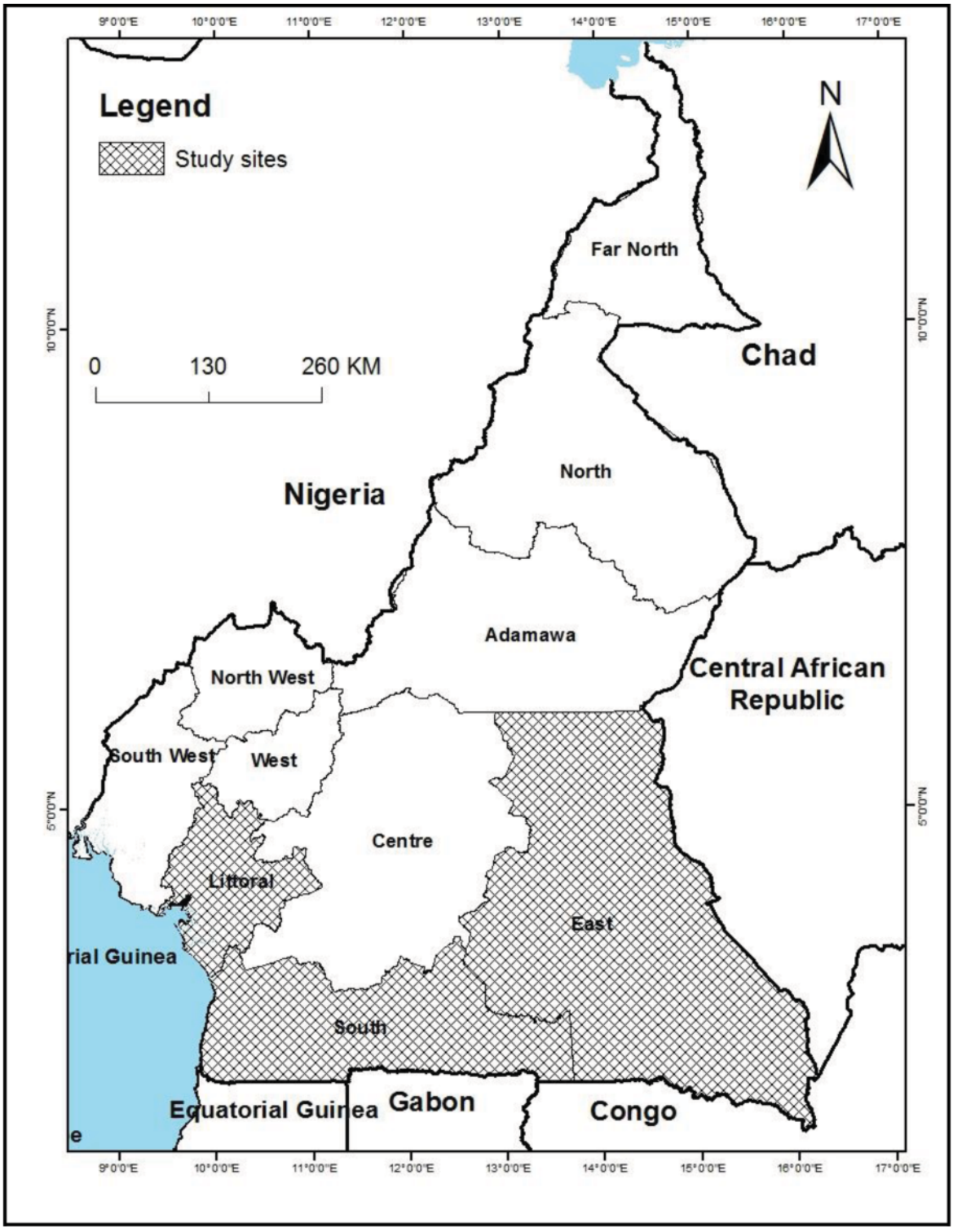
Geographically, Cameroon is located virtually at the centre of Africa, covers about 475,000 km^2 and is bordered by five countries: Nigeria, Chad, Central African Republic, Equatorial Guinea, and Gabon (Figure 1).

The country is divided into ten administrative regions and endowed with significant natural resources, including oil and gas, high value timber species, minerals, and agricultural products such as coffee, cotton, cocoa, maize, cassava (World Bank 2015). The total surface area of Cameroon's forests is 23 035 630 ha representing 48.73% of the national territory (Alemagi 2011). The private sector is mainly linked to the production forests where exploitation and management take place under four forest management models and partnerships arrangements, representing varying proportions of total forests: forest concessions - 30.64%; community forests - 8.04%; council forests - 6.71%; and sale of standing volumes - 1.65% (Tieguhong 2016a). According to Cerutti *et al*. (2016), there are 91 forest concessions composed of 106 forest management units (FMUs). The top five companies having large concession areas include PALLISCO Company Limited (PALLISCO in short), SEFAC, Filière Bois, CIBC and SEBEC (Tieguhong 2016a). The study area is located in the East, South and Littoral Regions of the country (Figure 1). The three regions constitute over 80% of the humid forest resources of the country (MINEFI 2006).

Study design

Stakeholders' consultations and analyses were conducted to identify the study sites and NGOs working on forest and climate change-related activities such as reforestation, afforestation, adopting reduced impact logging in forest concessions and reduced impact of the exploitation of wood in mangroves. In this regard, a list of actors in the private forestry sector in Cameroon engaged in primary and secondary forest production was drawn that consisted of private companies, Non-governmental Organisations (NGOs) and other private sector players in forestry. These resulted to the following actors: 96 companies involved in primary forest production of which top 20 were; SIM, SFID, CCT, ALPICAM, PALLISCO, FIPCAM, KEIFFER, TRC, SEEF, CFC, JDF, BOISCAM, SLES, NAMBOIS, GWZ, TTS, MPACKO JP, FEEMAN, CUF and SEFAC; 130 companies involved in secondary forest production of which top 20 were; ALPICAM, SFID, GRUMCAM, SIM, STBK, GWZ, SEFAC, CIFM, CCT, FIPCAM, SMK, CUF, TRC, SEEF, SFIL, CAFECO, SEBC and GVI; eight NGOs and five private sector players in forestry. Further screening was carried to identify which of these actors were involved on climate change activities in order to draw a representative sample for data collection. Purposive sampling was used due to fewer number of actors involved in climate change mitigation and adaptation activities (Table 1). This resulted to selection of one logging company (PALLISCO), four active NGOs and two private sector

FIGURE 1 *Map of Cameroon and the study regions*



Source: Authors

partners in forestry involved in climate change mitigation and adaptation initiatives. Interviews were conducted with selected actors through focus group discussions and via web-based or face-to-face approaches. In order to obtain more data, on-site visits were carried out in one forest concession areas in the eastern region and two forest communities in the South and Littoral regions of Cameroon. The primary data collection focused more on forest-based climate change activities especially on mitigation and adaptation responses, forest management activities aimed at carbon stock enhancement, increased primary and secondary forest production, business performances, engagement on carbon markets and trading, challenges of private forestry sector in face of climate change and how such challenges need to be addressed.

TABLE 1 *Profiles and interventions of key private sector actors*

Private sector actor		Climate change-related aspects and interventions	
Name	**Profile**	**Adaptation**	**Mitigation**
PALLISCO Company Limited (PALLISCO)	Private forestry company	Respect of management plan and collaborated in implementation of the FORAFARMA project	Support local communities plant trees that provide NTFPs for income and food security
Organisation for the Environment and Development (OPED)	NGO	Looking for a 2nd phase of the reforestation project in mangroves	Continue to work on scaling up improved fish-smoking techniques
Center for Environment and Development (CED)	NGO	Continue with the mentoring of communities	Continuation of the PES process
Cameroon Wildlife Conservation Society (CWCS)	NGO	Continue with work on mangrove reforestation	
Cameroon Ecology (CAMECO)	NGO	Looking for a second phase of the PACC project	Working on the forest carbon stocks in mangroves
MTN-Cameroon	Non-forestry private sector partner	No relevant information	Support to tree planting in drier northern regions of Cameroon
GUINESS-Cameroon	Non-forestry private sector partner	No relevant information	Support to tree planting in urban centres

Source: Authors' compilation

Secondary data was collected from literature reviews of scientific papers and technical reports to extract information on primary and secondary forest production, involvement on private forestry sector on climate change activities, emerging players (NGOs and other private actors) on climate change that supports forestry sector, the challenges associated with climate change on forestry sector, policy and institutional arrangements addressing climate change mitigation and adaptation.

Data analysis and reporting

Qualitative and quantitative statistical approaches were employed in analyzing data collected. Specifically, content analysis was used to develop appropriate themes as emerged from focused group discussions and other structured interviews with various actors in private sector forestry and climate change. The same approach was used on deducing the information from desk review of relevant technical reports, scientific papers, policy documents and documents of grey literature. Quantitative statistical approaches especially descriptive statistics were used to analyse data on primary and secondary forest production with a specific focus on exports of wood products for the period of 2009 to 2014 as obtained from Commerce du bois Cameroun (COMCAM). The results were presented both in tables and figures.

There are no carbon sales yet in Cameroon, which means business performance analysis of the private sector with respect to carbon was not possible. Therefore, the tangible engagement of the private sector in climate change is still embryonic in accordance with the evolution of REDD+ process in the country.

RESULTS AND DISCUSSION

Typology of key actors in Cameroon

Cameroon's timber industry mainly depends on its natural forest estate with wood harvested from a handful of species of commercial value to produce a diversity of products (Tieguhong 2016a, Neba *et al*. 2014). As a result, most logging is selective, with yields averaging only 5 m^3 ha^{-1} (Neba *et al*. 2014). However, with Asia rapidly surpassing Europe as the primary market for Cameroonian wood, the trend may be toward more intensive harvesting. This is because Asian buyers are interested in a wider range of species than their European counterparts (Tieguhong 2016a). The diversity of forest products matches with the diversity of services and actors involved in forestry related activities (Chia 2011, Dkamela 2011). In Cameroon like in most countries of central Africa, production and other interventions in the forestry sector are under government control (Tieguhong 2016a, Topa *et al*. 2009). Wood production is mostly managed by private investors, mainly large concession holders. According to Tieguhong (2016a) key actors in the private forestry sector can be grouped into five:

- Large multinational forest companies;
- Local councils;
- Community or cooperative enterprises applying SFM, like small-scale forest owners;
- International and local NGOs; and
- Emerging players such as the Mobile Telecommunications Network (MTN) and Guinness Cameroon.

TABLE 2 *List of primary wood production companies - Logs production and export (m^3)*

Companies	2009	2010	2011	2012	2013	2014	Total	% total
SIM	42510	67249	83817	94070	97326	84953	469925	13.42
SFID	61885	70308	72268	64167	73167	69109	410904	11.73
CCT		16298	31164	37585	93319	138874	317240	9.06
ALPICAM	27865	38718	41361	46743	44701	49673	249061	7.11
PALLISCO**	35964	42474	34070	31036	35913	24729	204186	5.83
FIPCAM	26336	37174	22867	25421	40394	20689	172881	4.94
KIEFFER	50870	34491	16158	6598			108117	3.09
TRC	19907	38182	35664	5507			99260	2.83
SEEF	8021	15901	5480	11583	9309	23366	73660	2.10
CFC	12551	17342	11390	6982	6599	15101	69965	2.00
JDF	1398	6242	8560	6998	20275	22186	65659	1.87
BOISCAM		0	0	0	14430	48495	62925	1.80
SLES		8901	14466	13968	6986	14473	58794	1.68
NAMBOIS	7707	14886	14099	9565	4591	7807	58655	1.67
GWZ	17051	22914	13024	2862			55851	1.59
TTS	28580	16763	10339				55682	1.59
MPACKO JP		17104	23363	14073			54540	1.56
FEEMAN		0	0	1083	12418	39679	53180	1.52
CUF	6195	12707	5195	2911	3806	10844	41658	1.19
SEFAC	10152	9686	4528	8900	2312	3601	39179	1.12
Top 20	**367144**	**497026**	**452341**	**398952**	**467858**	**577180**	**2760501**	**78.82**
76 others	**45493**	**110624**	**129960**	**97919**	**154679**	**203041**	**741716**	**21.18**
Grand total	**412637**	**607650**	**582301**	**496871**	**622537**	**780221**	**3502217**	**100**

Source: Authors' calculations from COMCAM Reports (2009–2014), ** actively involved in climate change activities

Indeed, forest products enterprises eligible for public-private partnerships (PPPs) fall under community forest enterprises (CFEs), council forests, forest concessions and sale of standing volumes (Tieguhong 2016a). The engagement of larger companies (forest concessionaires) is mainly a direct business partnership with the government implying that they form an important segment in all REDD+ initiatives. However, the local communities form part of the benefit sharing mechanism.

Private forestry sector actors in primary forest production

In this paper, primary forest production includes managing natural forests, forest plantations, woodlots, agroforestry, and farmer-managed regeneration. However, the most dominant forest management and production regime in Cameroon is in natural forests conducted by logging companies known as timber concessionaires (Topa *et al*. 2009). Foreign companies play a disproportionately important economic role in the logging sector probably because of their accessibility to international capital from financial institutions. The table below gives an overview of primary wood production companies in Cameroon with only one company (PALLISCO) that is currently engaged some climate change-related activities with various actors. PALLISCO for instance, exported 204 186 m^3 of logs or about 5.8% of the 3 502 217 m^3 of logs exported from Cameroon from 2009 to 2014 (Table 2).

Private sector forestry actors in secondary forest production

Most of the forest companies involved in primary forest production are also in the secondary wood production with the top ten companies exporting 80% of the sawnwood during the 2009 to 2014 period (Table 3). Only PALLISCO has over the years been engaged in climate change-related activities and has been involved in the production of 0.04% of the 3 539 297 m^3 of sawnwood exported from Cameroon over the reporting period (Table 3).

Emerging players on forestry related activities and climate change

Some new and emerging players are gaining prominence in forestry related activities that are linked to climate change.

TABLE 3 *Companies involved in secondary wood production, export of sawn wood (m^3)*

Companies	2009	2010	2011	2012	2013	2014	Total	% Total
ALPICAM	7790	238001	28692	28007	33643	31078	367211	10.38
SFID	43938	126544	48786	46862	50066	47683	363879	10.28
GRUMCAM	22481	65343	34094	97511	37831	31728	288988	8.17
SIM	30833	35180	43604	43201	45747	52387	250952	7.09
STBK	20082	26179	27616	29673	33394	33821	170765	4.82
GWZ	26938	21867	88914	23912	4465		166096	4.69
SEFAC	15700	26573	24601	17199	21270	31645	136988	3.87
CIFM	19365	23040	22801	20727	21958	21277	129168	3.65
CCT	6606	9943	12240	14968	57622	19221	120600	3.41
FIPCAM	13461	11691	17100	18114	34802	16210	111378	3.15
SMK	13666	18159	17800	18505	17787	20520	106437	3.01
CUF		6461	13055	16541	26029	26606	88692	2.51
CFC	12465	14121	14818	12909	13778	15601	83692	2.36
TRC	25801	26703	18425	9782	2160		82871	2.34
SEEF	12052	15012	15121	11284	12767	13430	79666	2.25
SFIL	12243	13249	12035	9652	10316	11829	69324	1.96
CAFECO		8295	12569	13042	11680	17653	63239	1.79
SEBC	4613	10891	11810	11171	11533	12756	62774	1.77
SEBAC	7426	10121	11088	10529	7841	2691	49696	1.4
GVI	5416	8771	9617	8344	6628	8649	47425	1.34
Top 20	**300876**	**716144**	**484786**	**461933**	**461317**	**414785**	**2839841**	**80.24**
110 others	**64110**	**92479**	**108585**	**129296**	**128598**	**176388**	**699456**	**19.76**
Grand total	**364986**	**808623**	**593371**	**591229**	**589915**	**591173**	**3539297**	**100**

Source: Authors' calculations from COMCAM Reports (2009–2014data)

These include local NGOs engaging with private business enterprises to conduct reforestation and forest restoration projects as well as partnerships between conservation NGOs and multinational companies producing other products and services within the country. Examples include Organisation for Environement and Developement (OPED), Cameroon Ecology (CAMECO) and Cameroon Wildlife Conservation Society (CWCS) that are working on the restoration and regeneration of mangroves in the country. The Center for Environment and Development (CED) and some local communities are also working together to enhance forest carbon stock in community forests. The activities of CED with forest communities consist of protecting dense primary forest zones, income generating activities and reforestation in the secondary forest zones and agricultural zones (fallows). Examples of partnerships between conservation NGOs and multinationals include MTN-Cameroon engaging with World Wide Fund for nature (WWF) Cameroon in 2006 to plant trees in the Northern regions of Cameroon and Guinness-Cameroon engaging with the Urban council in economic capital city of Cameroon, Douala to plant trees in the city (Tieguhong 2016a).

Climate change adaptation and mitigation responses

The private sector is a relatively newcomer to climate change adaptation, although many companies have a long-standing focus and commitment to environmental sustainability and social responsibility contracts. To date, most businesses concerned with climate change have focused more on reducing their GHG emissions to mitigate climate change than on responding to current and evolving climate change risks and impacts (Chia *et al*. 2013). The reasons for this, include: risk and uncertainty, lack of information and modelling tools, difficulty in communicating and championing adaptation inside the company, challenges of mainstreaming climate risk and opportunity analysis into core business processes, and lack of contemporary incentives to act (Pieters *et al*. 2013).

Climate change adaptation responses

According to Pieters *et al*. (2013), the private sector in Cameroon is engaged in climate change adaptation activities and "climate-proofing" operations. Climate proofing is a risk-based approach to climate change adaptation to manage both the current and future risks associated with atmospheric and

oceanic hazards (ADB 2005). In some instances, they develop activities geared at helping vulnerable populations in developing income generating activities from more efficient and energy conserving production systems. Examples of adaptation activities include the collection and commercialization of non-timber forest products (NTFPs) by local people to provide an increased source of income for people living in or near forests (Tieguhong *et al*. 2009 2012) and in situations of crop failures or low crop returns (Brown and Crawford 2007, Ndoye and Tieguhong 2004). If properly managed, NTFPs can be an incentive for forest communities to protect existing forests and restore degraded areas, and this ensures that their source of income is sustainable (Tieguhong and Nkamgnia 2012, Sonwa *et al*. 2009).

Other examples are drawn from national and international NGOs that are working closely to model adaptation tools in climate risk reductions. Cameroon Ecology (CAMECO) is a local NGO working closely with communities to reduce their vulnerability to the effects of climate change. They developed adaptation strategies for the communities of Ndokohi, Londji 1 and Ngonga (Masso and Ndjebet 2013). CAMECO is involved in the capacity building of stakeholders, local communities and councils in the sustainable management of natural resources, local governance, local economy, while considering gender issues linked to environmental protection (Ndjebet Cecile, Per. Comm). In 2013, the NGO received funding for a very relevant climate change adaptation project titled. "Project for reducing the vulnerability of Edea and Kribi communities to Climate Change impact". The project improved water availability to the construction of boreholes and improved household waste management. The boreholes lead to reduction in the workload of women and children who used to travel long distances to fetch drinking water (Masso and Ndjebet 2013).

Another project implemented by the Organisation for the Environment and Development (OPED) had an objective to develop alternatives to the degradation of mangroves for the wellbeing of women in Central Africa through improved fish smoking technologies. This led to 90% reduction in wood consumption from mangroves, thereby significantly reducing the rate of deforestation of mangroves (OPED 2014). The project facilitated the involvement of vulnerable women, who depend on mangrove ecosystems for their livelihoods, to participate in production techniques that ensure the conservation of these forests. The main activities of the project were improved fish smoking techniques (Figure 2); aquaculture development of freshwater shrimp and consolidation of the value chain for women.

The project led to poverty reduction and improved the income of women beneficiaries by 30% and reduced women's work drudgery by more than 66% and therefore an overall better quality of life for women who are no longer exposed to the heat of fish-smoking (Kono and Ndjeudja 2014).

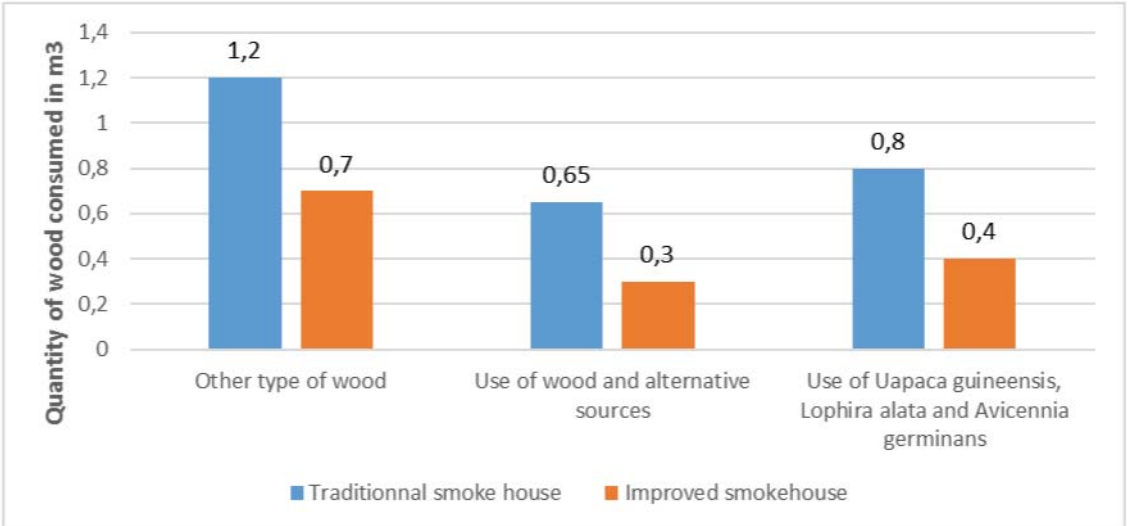
Climate change mitigation responses

Mitigation of climate change is an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases (AFF 2011), which was previously given greater consideration in climate change initiatives despite relevant synergies with adaptation strategies (Chia 2011, Locatelli *et al*. 2011, Ayes and Huq 2009, Chia *et al*. 2016b). In Cameroon, examples of climate change mitigation responses are drawn from the activities of three national NGOs (OPED, CED and CAMECO) and one logging concession (PALLISCO Company Limited, known in short as PALLISCO).

Engagements of PALLISCO and Partners on forestry and climate change activities

PALLISCO and partners are noted for ensuring sustainable forest management in Cameroon with approved management plans for all their FMUs. To guide environmental and SFM activities, PALLISCO embarked on a long-term Environmental Policy established on 25 April 2006. Under this policy guidance, activities related to climate change mitigation include:

FIGURE 2 *Energy efficiency of improved smokehouses (Pouokam 2013)*



- Methods of Reduced Impact Logging (RIL): Training given to logging teams (directional felling, skidding, creation and closure of logging parks in the forest) helps in improving the competence of field teams and reduce damage related to felling operations.
- Afforestation: Through partnerships and use of the nursery (established in 2002), scientific planting tests have been carried out in different models. An additional partnership with NATURE+ provides an ongoing technical support on a large-scale afforestation programme in all forest concessions exploited by PALLISCO (TEREA 2013).

All exploitable trees minimum exploitable diameter (MED), measured at 1.3 m diameter at breast height (dbh), is set by the government of Cameroon in charge of forests. The MED varies from 50 cm to 100 cm depending on the tree species of interest. For instance, eight out of the 30 tree species (*Eribroma oblonga, Detarium macrocarpum, Ceiba pentandra, Albizia ferruginea, Nesogordonia papaverifera, Staudtia kamerunensis, Swartia fistuloides and Erythrophleum ivorense*) exploited by Pallisco have 50 cm as their MED while four (*Pericopsis elata, Milicia excelsa, Baillonella toxisperma* and *Entandrophragma cylindricum*) have their MED fixed at 100 cm. The minimum management diameter (MMD) is greater or equal to the MED and published in the management plan of each Forest Management Unit (FMU) as deemed necessary by the logging company and validated by the administration in charge of forests. For most tree species exploited by PALLISCO, the MED=MMD except for 11 species: *Triplochiton scleroxylon, Piptadeniastrum africanum, Eribroma oblonga, Terminalia superba, Ceiba pentandra, Pycnanthus angolensis, Entandrophragma candollei, Nesogordonia papaverifera, Staudtia kamerunensis, Pterocarpus soyauxii,* and *Erythrophleum ivorense* (Tieguhong 2016b).

Nursery operations and tree planting

Since 2007, PALLISCO is carrying out nursery activities as part of its sustainable forest management plan. The seedlings produced in the nursery are directed to four different uses:

- the enrichment of the forest through the reforestation of open areas or logging gaps;
- the marking forest concession boundaries, which is an obligation from the forestry administration that every concessionaire should clearly delimit its concession boundaries;
- support village planting or local reforestation in favor of maintaining local traditions and other forest benefits such as the sustainable provision of NTFPs.
- promote forestry research in test plots in regeneration and reforestation trials and techniques for specific tree species (TEREA 2013).

Indeed, from April 2002 to October 2007, PALLISCO attempted nursery operations with 22 out of the 30 species exploited with varying degrees of success. Germination rates vary from less than 40% for some tree species (*Canarium schweinfurthii*, *Guarea cedrata*, *Eribroma oblonga*, *Staudtia kamerunensis*, *Milicia excelsa*, *Entandrophragma utile*, *Erythrophleum ivorense*) to over 80% for some (*Baillonella toxisperma*, *Lovoa trichilioides*, *Afzelia africana*, *Entandrophragma angolense*). Over the same period, PALLISCO enriched its forest concessions with 10,473 seedlings, planted 5,038 to mark forest concession boundaries, distibuted 569 seedlings to villagers to plant, used 6,204 seedlings in field trial experiments and planted 15 seedlings of Assamela under plantation conditions.

Engagements by NGOs and partnerships with multinational companies on forestry and climate change

Cameroon Ecology (CAMECO) also benefited from the financial supports of the International Tropical Timber Organisation (ITTO) and Congo Basin Forest Fund (CBFF) to implement a reforestation project in degraded areas in the Sanaga Maritime Division of the Littoral Region of Cameroon. The proper implementation of the project was supposed to lead to the reforestation of 1500 ha of forest comprising of 5 ha of an important NTFP for communities (Masso and Ndjebet 2013). Another project *"Sustainable Community Based Management and Conservation of Mangrove Ecosystems in Cameroon"* funded by CBFF, was implemented by OPED in collaboration with CWCS to reforest 5 ha of mangroves using 12 000 plants of *Rhizophora* spp. (OPED 2014).

Tree planting partnerships driven by MTN and GUINESS Cameroon have been documented in Cameroon. In the Northern part of Cameroon, the MTN Foundation in partnership with WWF developed an environmental education programme called "Tree for Life". To fight against desert encroachment, the MTN Foundation funded tree-planting operations in the northen part of Cameroon to consolidate the sustainable management of natural resources. In the first phase of the programme 250,721 trees were planted with a survival rate of 70%. During this phase, the amount invested by MTN was 100 million CFA Francs. Almost ten NGOs are involved in this program (NembotNdeffo 2009). Similarly, the GUINESS Cameroon Foundation went into partnership with the Douala Urban Council to launch the "Operation 10,000 trees" that enabled the company to deploy its employees to plant trees in the city of Douala in July 2009. In the first phase, these employees planted 300 shrubby trees in the city of Douala in collaboration with the officials of the Metropolitan city (Nembot-Ndeffo 2009).

Management activities to enhance forest carbon stocks

As stated earlier, any company wishing to operate in a timber concession in Cameroon must first submit a management plan for approval by the Ministry of Forest and Wildlife. The same approach is mandatory by the Forest Stewardship Council (FSC). The drafting of such a plan is based on data acquired by management inventories, generally covering about 1% of the concession area. Aside from cash and estimated volumes of the trees concerned, tree diameters are among the data variables measured and recorded. From the

diameter of a tree, infra-density of the species to which it belongs and the type of forest in which it grows, it is possible to calculate its biomass using equations available in the literature (Gibbs *et al*. 2007). Tree biomass is composed of 50% carbon, the diameters noted during the management inventories ultimately allow to obtain an estimate of the carbon contained in the concession forests. In this sense, this approach is inherent to every responsible exploitation involved in estimating quantities of carbon stocks in forest, as a first stage of REDD/REDD+ (Boundzanga 2013). Furthermore, FSC certification requires the implementation of an ambitious program of the rehabilitation of disturbed sites following the passage of exploitation such as logging gaps, old logging yards and gantries. Reforestation of these degraded areas with seedlings of species exploited encourages recolonization of the forest by tree seedlings of high carbon storage potential because the bulk of harvested species include large long-lived trees. Such enrichment plantings could enhance the recovery of biomass and carbon stock removed by past logging operations, which forms an important part of the REDD+ process. Similarly, reduced impact logging such as removal of one or two trees per hectare per rotation, long rotation, controlled felling techniques and skidding, as advocated by the FSC certification standards help in streamlining timber extraction and reduces damage to the residual stand. Cameroon's forest ecosystem supplies goods and services for local livelihoods and national development. As climate change will have an undesirable impact on the functioning of the forest ecosystem, the livelihoods of the people that depend on forests will become inevitably vulnerable (Chia *et al*. 2016b). Conservation and SFM for climate change mitigation and adaptation are among the main responses to this challenge. The Cameroon private sector has taken some conservation and SFM initiatives that could potentially contribute to climate change mitigation and adaptation.

National and international policies, legislation and institutions related to climate change

Cameroon's 1994 Forestry Law divides its forest into two domains: a Permanent Forest Estate (PFE), which is a protected forest sustainably managed according to approved plans, and a Non-Permanent Forest Estate (NPFE) that is set aside for development, where conversion may be allowed. According to the Cameroonian forest policy, permanent forests must (a) cover at least 30% of the national territory, (b) be representative of the national biodiversity in order to guarantee their sustainable use, (c) be managed according to a management plan approved by the Ministry Forestry and Wildlife (MINFOF). Protected areas, such as national parks, are part of the permanent forest domain. Therefore, all activities related to mitigation and adaptation must be implemented in this area (Topa *et al*. 2009).

The government's responsibility for forests is vested in a single ministry, the Ministry of Forests and Fauna (MINFOF). However, the common responsibility for forests between MINFOF and the Ministry for Environment and Protection of Nature (MINEPDED) is defined by a joint 2005 Forest and Environment Sector Policy Letter with MINEPDED being responsible for climate change adaptation and mitigation. In Central Africa, Cameroon has made good progress towards SFM in some selected forest management units (FMUs) including those of PALLISCO and partners. Cameroon has an estimated 12.8 million hectares of permanent forest estate (PFE), comprising 7.60 million hectares of natural production forests, 5.20 million hectares of protection forests and 19 000 hectares of industrial timber plantations (FSC 2015). At least 1.25 million hectares of natural-forest production PFE are estimated to be under SFM. Forest management plans have been developed for and are being implemented in 5.0 million hectares of the production PFE. FSC third-party certification has rapidly progressed and currently about 1 million ha of forests in the country have forest management certificates (FSC 2015, Teketay *et al*. 2016).

Cameroon ratified the United Nations Framework Convention on Climate Change (UNFCCC) on 19 October 1994 and the Kyoto Protocol on 23 July 2002 but has not yet created a policy document on climate change or an operational plan to implement these instruments. The UNFCCC stipulates that all countries have the commitment to promote the sustainable management of sinks and reservoirs of all greenhouse gases, including biomass, forests and other ecosystems (UNFCCC 1997). The Kyoto Protocol of the UNFCCC sets commitments for developed countries to stabilize their greenhouse gas emissions in the period 2008–2012. According to the Protocol, developing countries are also accountable for emissions resulting from land use changes. This implies that developing countries have a clear incentive to reduce deforestation and greenhouse gas emissions resulting from deforestation. The fundamental objective of the forest policy reform in Cameroon was to establish a transparent, equitable, and sustainable management system for forest resources (Topa *et al*. 2009).

Although Cameroon ratified the UNFCCC and the Kyoto Protocol over two decades ago, the country is yet to create a policy document on climate change or an operational plan to implement these two instruments (Chia 2014, Dkamela 2011). The first national document on climate change, made public in 2005 (MINEF 2008), sets out a long list of climate-support activities that are related mostly to instruments and operational plans connected to the Rio Declaration of 1992. Other notable documents are the 1995 National Forest Action Programme (NFAP) adopted in 1996, the National Environmental Management Plan (NEMP) adopted in 1996, the National Biodiversity Strategy and Action Plan (NBSAP) of 1999, the National Action Plan to Combat Desertification (NAP/CD) of 2006 and the National Energy Action Plan for Poverty Reduction (PANERP). In the first national document (MINEF 2008), adaptation and emissions reduction measures were presented as worthy of consideration.

Whilst very few laws in Cameroon are related directly to REDD+, many laws have been established that outline a system for conserving forests and defining property rights and land tenure that therefore provide a framework for the development of REDD+ in Cameroon. One of the few REDD+ specific laws in Cameroon is Decision No.09/MINEP of

15 January 2009 on the creation of a Steering Committee for REDD+ in Cameroon in charge of political, technical and strategic orientations of the REDD in Cameroon. The Committee also approves roles and responsibilities of stakeholders in the REDD+ process, provides advice to the Central African Forests Commission (COMIFAC) on the UNFCCC negotiations and acts as the REDD+ focal point in Cameroon. Other laws that are significant in Cameroon are the 1994 Forestry Law, which reformed the 1982 Forestry Code and provides clear orientations toward sustainable forest use, and Decree No.2009/410 of 10 December 2009, which established the National Observatory on Climate Change (ONACC). In the area of climate change, Cameroon is in the process of elaborating national adaptation and mitigation strategies in collaboration with the United Nations Development Program (UNDP) and other partners. A dedicated climate change unit was established in 1999 within the ministry in charge of the environment, and the National Implementing Entity, known as the National Climate Change Observatory (ONACC) which has been legally established since 2009 (GoCam 2013 2016).

Cameroon as a country has engaged in several relevant bilateral and multilateral arrangements that are directly or indirectly linked to climate change, not only in terms of forest production and management but also in terms of the conservation of biodiversity and socioeconomic concerns linked to local populations. An example is the World Bank's Forest Carbon Partnership Facility (FCPF) on REDD+ readiness where the government has put forward a REDD+ strategy with a defined institutional, governance and policy framework. In addition, Cameroon is also involved in the FCPF Carbon Fund results-based payments initiatives, with an Emission Reduction Program Idea Note (ER-PIN) that was validated recently (GoCam 2016). The activities in the ER-PIN are in line with the vision of the REDD+ strategy, which is to make REDD+ a tool for Cameroon's sustainable development. The ER-PIN will address activities related to reducing emissions and increasing removals (GoCam 2016). The total aboveground and belowground biomass in the programme area is estimated at 1,725 Mt C/1.725 Gt of biomass, which is approximately 37% of the country's total carbon stocks (GoCam 2016). Cameroon's Nationally Determined Contribution (NDCs) outlines the country's mitigation commitments, whereby land use and forestry are given due consideration. Historic rates of deforestation and forest degradation are projected to increase substantially with the national goal of transforming the economy and making the country emergent by 2035. The strategy is thus aimed at addressing measures for a low carbon impact development pathway. The programme will also be designed to bring all relevant actors together within a sub-national strategy for local development and climate change mitigation in line with the National REDD+ Strategic Framework.

Challenges to private sector engagement in mitigation and adaptation activities

The practical challenges encountered by the private sector in engaging in mitigation and adaptation activities in Cameroon could be linked to legal and administrative issues, land and forest hunger, overlapping government development priorities, institutional weaknesses and gender disparities.

Legal and administrative issues: Cameroon's Forestry Law divides its forest PFE covering 80% and a NPFE that makes up the remaining 20% (Topa *et al*. 2009). Whilst both areas are under some form of state control, they differ in terms of how the state can grant user rights to the private sector. Ordinance No. 74/1 of 6 July 1974 establishes the rules governing land tenure in Cameroon, whereby all land that is not privately registered is owned by the state. However, in practice, obtaining a land certificate is quite a rigorous, remote, complex and expensive process as well as subject to corrupt procedures. This might continue to undermine the efforts of private forestry sector interested on carbon stock enhancement activities as well as taking emerging opportunities of REDD+ and market incentives. For instance, studies have shown that successful REDD+ pilot projects in Democratic Republic of Congo, Ethiopia, Kenya, Tanzania, Mozambique, Zimbabwe and Madagascar have been spearheaded by the private sector on private land and in some cases on public land facilitated by the Governments (Oeba and Larwanou 2017, Oeba and Larwanou 2015). The authors reported that some of these REDD+ pilot projects developed by private sector focused on promoting sustainable land use practices in forest adjacent communities; development of alternative livelihoods in forest adjacent communities; building local and national capacity on understanding REDD+ mechanisms; contribution to National REDD+ strategies and policies and building village-level, local government and civil society organizational capacities toward understanding REDD+ in view of participating in future global forest carbon trading.

Perrsistence of illegal logging and corruption: Illegal logging has long been a major concern in Cameroon and illegal practices occur at many stages from the issuance of fake concession permits that are not registered in the official figures to illegal transport and export processes that do not comply with official annual cutting limitations (Dkamela 2011). Although there is now a quarterly publication of illegal logging cases and fines, only a small proportion of fines are actually paid and, in some cases, fines are negotiated down to between 70–98% of their initial amount (Dkamela 2011). Moreover, Cameroon does not have a formal system for addressing safeguards at the national level.

Overlapping government development priorities: One of the main underlying drivers for deforestation may be the Government of Cameroon's ambitious Vision 2035 which aspires to make Cameroon an emerging economy by 2035. According to Cameroon's Readiness Preparation Proposal (R-PP), the main drivers of deforestation and forest degradation are agriculture, particularly shifting slash and burn cultivation, and wood extraction (GoCam 2013). The country's development policy as laid out in the Growth and Employment Strategy Paper (GESP) bases the country's growth on infrastructure development, modernization of the productive sectors such as agriculture and regional trade integration, amongst others. For example, the expansion of agricultural

lands will mostly be done in forested landscapes and therefore, deforestation will likely be the direct consequence, especially in the absence of agricultural intensification techniques. Similarly, Cameroon currently grapples with land grabbing and high demand for farmland by multinationals and the domestic elite (Nguiffo *et al*. 2012). Cameroon has no regulation on carbon ownership per se, although it is likely the carbon is owned by the owner of the land. It will be difficult to determine who owns the carbon credits when land tenure is not clearly established.

Institutional weaknesses: The Ministry of Social Affairs and the Ministry of External Relations are currently carrying out a study to identify the groups that are considered indigenous, which is often considered a controversial topic in Cameroon. While several governmental agencies are to be engaged in the design and implementation of the REDD+ strategy, very few have the actual capacity to engage and are therefore not effectively involved in the process. Further, MINEPDED has relatively fewer financial resources compared to other ministries such as those on forestry and mining, and its mandate to engage with those other ministries is considered weak.

CONCLUSIONS AND RECOMMENDATIONS

Certain human activities such as logging by the private forestry sector have been identified as significant contributors to climate change. In most countries in Central Africa, including Cameroon, forests are central to both mitigation and adaption strategies (Chia *et al*. 2013, Bescond 2013). Logging companies are the traditional private sector players in forestry but their active participation in climate change-related activities is still low in Cameroon. However, because of the growing global concern of climate change, newcomers and emerging players are gaining prominence, such as conservation NGOs, corporate businesses and multinationals working in partnerships. Their efforts are geared towards developing interesting initiatives related to carbon sequestration, including afforestation, reforestation, restoration, agroforestry and efficient energy use. Cameroon possesses significant forest resources and has considerable potential for SFM. Thus, Cameroon has potential to develop REDD+ initiatives that address the threats that may lead to deforestation and forest degradation. This paper has raised many concerns related to the private sector engagement in climate change activities including the low active participation of forest concessionaires. The current scenario with only one concessionaire such as PALLISCO making active engagements in climate change-related activities in Cameroon is a testimony to the predicaments. Reversing the current scenario will require, but is not limited to, the following actions:

a) putting in place the correct institutional and policy environments to capture the full participation of the private sector,
b) overhauling strategies to ensure the active participation of several other logging companies in the country. The current positive developments such as the involvement of PALLISCO in Cameroon provides a good pilot for the success of the REDD+ initiative,
c) engaging several logging companies in climate change activities from a business perspective through climate change finance mechanisms such as the Forest Carbon Facility. This will enhance possibilities for achieving the move from logged to protected forests such that by eliminating harvesting for timber in certain forest areas, biomass carbon stocks are protected and can increase as the forest re-grows and/or continues to grow,
d) implementing the ambitious programme of the FSC's certification scheme that requires the rehabilitation of disturbed sites (such as logging gaps, old logging yards and gantries) after exploitation. The reforestation of these degraded areas with seedlings of exploited species encourages recolonization of the forest by tree seedlings of high carbon storage potential because the bulk of harvested species include large, long-lived trees,
e) resolving the challenge of over-exploitation of forests that results when the private costs of deforestation (mainly labour, capital, and transaction costs) do not include all the social costs (soil erosion, loss of bio- and cultural diversity, greenhouse gas emissions, and watershed degradation). These social costs need to be reflected in the prices for forest products to capture the true value of forests that may spur greater incentives for forest regeneration and SFM.

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