A PLATFORM FOR STAKEHOLDERS IN AFRICAN FORESTRY

PROSPECTS FOR REDD+ IN AFRICAN FOREST PLANTATIONS

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Prospects for REDD+ in African forest plantations

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Acronyms and abbreviations

AR	Afforestation and Reforestation
COP	Conference of the Parties
DRC	Democratic Republic of Congo
FAO	Food and Agricultural Organization
FCPF	Forest Carbon Partnership Facility
GHGs	Greenhouse Gases
GLP	Global Land Project
IPCC	Intergovernmental Panel on Climate Change
KP	Kyoto Protocol
MDGs	Millennium Development Goals
MRV	Monitoring, Reporting and Verification
NAMAs	Nationally Appropriate Mitigation Activities
NWFP	Non-wood Forest Products
REDD+	Reduced Emissions from Deforestation and Degradation Plus
UNFCCC	United Nations Framework Convention on Climate Change

Executive summary

This report examined the prospects of greenhouse gas mitigation in African tree Plantations, with a focus on the potential of Reducing Emissions from Deforestation and Degradation (REDD+) in Plantations.

Plantations constitute one out of every five hectares of world forests which currently add up to 4 220 million hectares. It is estimated that c. 16 million ha of plantations are growing in Africa, which is about 4% of all African forests, compared to a significantly higher global average of 7%. In recent years there has been an accelerated pace of planting in Africa, especially by the private sector and non-public actors.

Forest plantations are subject to the same factors that drive deforestation and forest degradation in general, albeit to a varying degree. This study reports that, since 1990, Africa has been losing an estimated 51 000 ha of plantations annually with a carbon stock averaging 30 t/ha. A further 200 000 ha are estimated to be in various states of degradation every year.

Interventions to reduce and/or eliminate carbon emissions through establishment of plantations could lead to substantial carbon benefits under the REDD+ programme given the eventual high carbon stocking of fast-growing plantations. Estimates using standard assumptions on carbon stocking in plantations suggest that about 40 million tonnes of CO_2 could be creditable to REDD+ annually.

The study further reviewed other mitigation activities possible in African plantations and most of these will fall in the category of “Nationally Appropriate Mitigation Activities” agreed on in Doha in 2012. Such activities may include biomass conservation, utilisation efficiency improvements, using plantation and wood industry residues for co-generation of heat and power, complimentary possibilities to establish new plantations for the production of biofuels, as long as it does not impinge on food security and exacerbate land conflicts where the resource is scarce. It is also recommended that African countries consider expansion of plantations as a REDD+ programme to relieve pressure on natural forests.

When applied to plantations, REDD+ has less community conflicts over tenure, ownership and access given the largely public ownership of plantations in Africa.

With the extent of plantations, and the significant rates of deforestation and degradation, it is recommended that plantations be opened to all mitigation options available in the forestry sector, especially REDD+. It is thus recommended that African countries involve plantations in climate change baseline studies and include MRV issues in the regular plantation management plans.

To allow for meaningful participation of plantations in GHG mitigation, African countries should foment the policy and institutional changes necessary within the forest management system.

Chapter 1 Background and objectives

BACKGROUND

Global climate change has become the preeminent problem of our times, with poor countries bearing the brunt of its ill-effects, given their vulnerability and diminished resilience and adaptive capacity. Africa appears to be at particular risk from negative impacts of climate change and has been a responsible member of the global community in efforts to fashion effective responses in the form of mitigation.

Climate change is now recognised as a major threat to achieving the poverty reduction aspirations of many African countries as well as the attainment of the Millennium Development Goals (MDGs). The phenomenon is affecting rainfall patterns, water availability and periodicity of precipitation, melting of ice and glaciers, sea level rise, increasing droughts and bushfire frequency, intensity and frequency of extreme weather events, all increasingly impacting human and animal health, agriculture and land productivity, vegetation cover and biodiversity. In general, climate change impacts the environment in which humans live, thus affecting the livelihoods of many and incomes of nations.

Forests form the largest ecosystem that significantly impacts global climate, while at the same time being affected by it. The most obvious negative impact is through emissions of greenhouse gases (GHG) resulting from deforestation and forest degradation. Forests also play a key role in adaptation to climate change, for example, by increasing the resilience of rural communities, and supporting adaptation of species to changing climate patterns and sudden climate events by providing refuge and migration corridors for wildlife. Also, they indirectly support economies to adapt to climate change by reducing the costs of climate-related negative impacts. Forest ecosystems also provide goods and services during extreme events (droughts, floods and extreme temperatures) and are key assets for reducing vulnerability to the effects of climate change. Also the role of forests in regulating the water cycle cannot be overlooked.

In terms of mitigation, forests have a considerable potential to sequester carbon through afforestation, reforestation, forest restoration and changes in forest management practices. Also included among forest-based mitigation measures are the efficient use of forest products, substitution of fossil fuels and products based on these by forest products, as well as replacing the use of unsustainably produced forest products by those which are sustainably produced. These potentials have been fully appreciated by the on-going global climate change negotiations, from the Kyoto Protocol (UNFCCC, 1997) through the Doha Gateway (UNFCCC, 2012).

The other significant role played by forests in climate change mitigation is GHG emission reduction. Between 10% and 17% of global GHG emissions are derived from the forest sector, mainly from deforestation, forest degradation and use of forest resources, which in turn allows for a commensurate intervention by reducing these emissions (IPCC, 2007). The range is determined by the fluctuation in deforestation rates in the key forested countries in the tropics. Efforts to reduce emissions in this sector will provide some breathing room for the world community to chart a way forward in arresting the increasing atmospheric concentration of GHGs, principally from the energy sector and industry.

The global policy negotiations aimed at increasing the scope of the forest sector in climate change mitigation through conservation of carbon stocks started at the eleventh session of COP11 in Montreal, Canada in 2005 and continued at COP12 in Nairobi, Kenya in 2006. Major advances were made at COP13 in Bali where Parties committed themselves to reducing emissions from deforestation and degradation (REDD) in the context of the post-2012 second commitment period under the Kyoto Protocol. Other options mentioned in the Bali roadmap included sustainable forest management, forest enhancement and conservation, the totality of these interventions giving rise to the term REDD-plus (REDD+). A critical point in connection with these decisions was the recognition of the needs and rights of local and indigenous communities as affected by actions arising from the roadmap. Finally, it was also agreed to begin pilot activities to support REDD as a mitigation option, while leaving some complicated technical issues such as baselines and leakage for further deliberations.

Although REDD+ was first concretised in the climate policy agenda in the Bali Action Plan in 2007, it was firmly defined in the 2010 Cancun Agreements to cover forest sector climate mitigation through five activities (Paragraph 70, Decision 1/CP.16, UNFCCC 2010):

1) reducing emissions from deforestation;
2) reducing emissions from forest degradation;
3) conservation of forest carbon stocks;
4) sustainable management of forests; and,
5) enhancement of forest carbon stocks.

REDD+ includes policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries while recognising the contribution of conservation, sustainable management of forests and enhancement of forest carbon stocks in achieving emission reductions. Essential to this model is to provide incentives that discourage deforestation and forest degradation thereby reducing emissions from these activities. In other words, REDD+ constitutes payment of environmental services (PES) rendered by standing forests (Wunder, 2005). Developing appropriate adaptation and mitigation actions include the improvement of forest management to reduce vulnerability and to mitigate GHG through REDD+.

Sub-Saharan Africa is expected to face significant impacts from climate change, both on economies and on social systems. Forests and trees will play crucial roles in helping to adapt to climate change and mitigate the increase of GHG concentration in the atmosphere. Strengthening and further developing the forest/climate nexus therefore is a key issue for Africa's future development.

The potential for REDD+ in Africa is enormous. The continent has 675 million hectares of forests (FAO, 2010) – about 16% of the world's total – with the Congo Basin harbouring the world's second largest block of rainforests after the Amazon Basin. Recent evidence shows that even drier Sahelian and sparser ecosystems can be made to increase their carbon stocks significantly (SKUTSCH AND BA, 2010). This raises the possibility that countries with largely dry forests might also be able to participate in and benefit from the REDD+ mechanism. As of now, it appears that this vast potential remains underexploited.

The emphasis of the African Forest Forum's "African forests, people and climate change" project is on development of the forest/climate change nexus in semi-arid areas (Sahel belt), the woodlands of West, East and Southern Africa and the moist forests in Central and West Africa, addressing each of the five main African tree-dominated groups of ecosystems, viz. Forests (dense and closed), Woodlands, Sahel (agrosylvopastoral parklands), Mangroves and Plantations.

Deforestation and forest degradation are processes that have mostly been discussed in the context of natural forest coverage. These two processes have not been widely covered in plantations because they are usually under management. Consequently, most REDD+ literature and plans give main attention to reducing emissions from deforestation and degradation from natural forests. African plantations have often been neglected.

This report seeks to contribute to a better understanding of the role of tree plantations in GHG mitigation and how to enhance their incorporation into the array of global efforts in mitigation. The term plantations is used in this context to include forest plantations, non-forest plantations such as rubber, palms, wattle, orchards, and indeed woodlots for production of wood fuel and poles.

OBJECTIVES

This report focuses on African forest plantation ecosystems and sets out to review and evaluate REDD+ activities. Specifically, the report:

- reviews and evaluates national and sub-national REDD+ activities implemented in forest plantations in Africa;

- evaluates the potential of and preconditions for increased implementation of national and sub-national REDD+ activities in plantations in Africa;
- identifies and describes best REDD+ practices in African forest plantations and evaluating the potential for up-scaling; and,
- identifies, analyses and evaluates other relevant mitigation activities in forest plantations in Africa and assessing their potential for up-scaling.

CHAPTER 2 Greenhouse gas mitigation in African tree plantations

Reducing emissions from forests and sequestering carbon in forests is a cost-effective option to reduce GHG emissions (SATHAYE ET AL., 2006). But forests are more than carbon.

The world's forests support the livelihoods of up to 1.6 billion people and provide habitat to 80 percent of the world's terrestrial biodiversity (MBOW, 2012). Sustainable management and protection of forests offer an opportunity to support climate-resilient economic development and protect biodiversity while accelerating poverty alleviation in some of the least-developed nations. As indicated above, the Parties to UNFCCC have negotiated a policy to reduce emissions from deforestation and forest degradation and enhance carbon stocks (REDD+). To achieve this, there needs to be predictable, long-term finance available to provide incentives for conservation and sustainable use of forests, the protection of biodiversity, and support to local communities whose livelihoods are linked to forests. Global economic studies (SOHNGEN AND MENDELSOHN, 2002; BOUCHER, 2008; ANGELSEN ET AL., 2009; NEPSTAD ET AL., 2006; SATHAYE ET AL., 2006; PAGIOLA AND BOSQUET, 2009) dedicated to estimating the costs of REDD+ find that the annual funding needs are in the tens of billions of dollars. Since the launching of the concept, various funding sources have shown interest in financing REDD+, with pledges not exceeding a few billion dollars. For example, the World Bank has been managing a growing number of funds designated for REDD+, including the Forest Carbon Partnership Facility (FCPF), the Biocarbon Fund, and the Forest Investment Fund, all of which have pledged funding totalling c. USD 1 billion. Individual countries, such as Australia, Norway, Germany, and UK, have also pledged a few billion dollars towards REDD+ readiness, pilot projects and operationalising the REDD+ mechanism. Furthermore, there are additional resources from philanthropic organisations such as Betty and Gordon Moore Foundation, David and Lucile Packard Foundation, the Linden Conservation Trust, etc., which have pledged and invested significant resources towards establishing an international framework for REDD+.

When these figures are considered, there is still an apparent significant funding gap. As a result, the international community has identified the need for a broader participation by the private sector. In 2011, at COP17 in Durban, South Africa, the Parties reached the important decision that financing REDD+ could engage the private sector and it was agreed that "appropriate market-based approaches could be developed by the COP to support results-based actions". Many market-based mechanisms for REDD+ are already either developed, under development, or anticipated in the future. Private sector capital has been responsive and has started to develop REDD+ activities and generate REDD+ credits in natural forests.

A global survey of REDD+ activities undertaken in 2009 showed a total of 22 REDD-readiness activities, the bulk of which (18) were in Africa (CERBU ET AL., 2011). These are experimental activities such as the promotion of sustainable forest management practices, forest conservation combined with incentive payment schemes, and monitoring systems that measure the change in carbon stocks, which may be site-specific or carried out at local to provincial scales. Demonstration activities are essential in order to establish a basic stock of practical experiences related to REDD+ that may inform national level implementation.

In this study, a desk review was undertaken of the extent of mitigation activities in existing forest and other tree plantations in Africa, with a focus on surveying existing REDD+ activities. Other mitigation options in the sector were also identified and ways of scaling them up via existing global mitigation and environmental policies are discussed.

THE CONCEPTUAL FRAMEWORK FOR REDD+ ACTIVITIES IN FOREST PLANTATIONS

To identify REDD+ interventions in a given forest ecosystem, one has to identify and understand the dynamics of the driving factors underlying land use and land cover change. There is a general consensus about the notions of proximate and underlying driving forces, which has been broadly accepted as a useful way of framing the analysis of land use change processes in an effort to identify general features of land use and land cover change (LAMBIN ET AL., 2003).

The driving forces of land use change are divided into direct (proximate) and indirect (underlying) forces. Proximate causes are human activities or actions that alter land use in a given locality, such as expansion of crop land or deforestation. Underlying driving forces are, in contrast, forces and processes in society that constitute the basis of the proximate causes. They operate at regional, national or global levels. Examples are changing market conditions, population growth, institutional factors or changes in resource property rights. The proximate and underlying driving forces are interlinked in complex positive and negative feedback mechanisms and the land change outcome of a number of given factors depends on the context. LAMBIN AND GEIST (2006) stress that the main message from various studies confirm the thesis that there is no evidence to support single-factor explanations in land system dynamics. No drivers operate in isolation and therefore it is important to focus on causal synergies and interactions between the driving factors in a given context when seeking to understand land use and land cover changes. This conceptual framework will be applied in understanding deforestation and degradation in forest plantations in Africa.

The emphasis in mitigating climate change in the forestry sector has evolved from Afforestation and Reforestation (AR) to Reducing Emissions from Deforestation and Forest Degradation (REDD) to REDD+. In the latter activity, forest degradation refers to less obvious changes in the woody canopy cover while deforestation is the more or less complete loss of forest cover that is often associated with forest clearance. Forest degradation therefore represents the temporary or permanent reduction in the density, structure, species composition or productivity of vegetation cover and presents difficulties of modelling it in African open woodlands and savannahs using remote sensing technologies alone (BOND ET AL., 2010). Depending on the agents and processes of forest degradation, this will often be accompanied with loss of carbon stocks in the litter and soil organic matter. Thus, in addition to use of remote sensing technologies, tracking forest degradation still requires the use of field inventories. Given that the process of forest degradation can be small scale and gradual, the use of permanent sample plots to monitor forest degradation is an essential tool to meeting REDD+ and biodiversity requirements and safeguards. These aspects of deforestation and forest degradation rise by an order of magnitude in complexity when they are applied to forest plantations.

STATUS OF PLANTATIONS IN AFRICA

In this report the term plantation is used to mean planted trees not always categorised as forests. Plantations in general are composed of trees established through planting and/or through deliberate seeding of native or exotic species. Establishment is either through afforestation on land that until then was not classified as forest, or by reforestation of land classified as forest, for instance after a fire or a storm or following clear-felling.

The concept of planted forests is broader than the concept of forest plantations that has been used in many forest resource assessments up until the FRA 2010. This change was made to capture all planted forests and is in line with the recommendations of the Global Planted Forests Thematic Study 2005 (FAO, 2006) and recent efforts to develop guidelines and best practices for the establishment and management of planted forests.

Planted forests are established for different purposes and not all of them are designated for production of wood or NWFPs. Based on the results of the above mentioned thematic study, it is estimated that around 76% of planted forests have production as their primary function (FAO, 2006, OP CIT). For the purposes of REDD+, this differentiation does affect the carbon accounting for the avoided emissions since they are contingent on the baseline intended function of the plantation. For example, the avoided emissions from a deforested part of a plantation managed on a basis of sustainable rotations is half of the carbon stocking in timber, litter and forest products, whereas the emission reduction for a plantation intended for conservation or restorative purpose would be the full amount of the carbon stock.

The detailed calculation procedures for carbon accounting in plantations are outlined in SATHAYE AND MEYERS (1995 OP CIT.). For the purpose of this report, the emission reduction is commensurate to the carbon sequestration for the plantation given the intended purpose. There are five carbon pools in a plantation, viz.:

1) above-ground vegetation carbon;

6) below-ground vegetation carbon;
7) detritus carbon – that which is in dead wood and litter;
8) soil carbon – that which accumulates from decomposing organic matter;
9) wood products pool – that which is retained in wood products eventually released via decomposition and/or oxidation at various times depending on the profile of use.

Estimating emission reduction from deforestation and degradation of forest plantations will take into account the dynamics of each pool.

EXTENT, DISTRIBUTION AND TRENDS OF FOREST PLANTATIONS

Data on the extent and trends in forest plantations are largely available from the FAO Forest Resource Assessments (FAO, 2005; FAO, 2010). Figure 1 below, based on such data, shows the proportion of the global forest cover that is constituted of planted forests, with Asia having larger area of planted forests than primary forests, occupying about 20% of all forest cover, while Africa has about 4% of its forest cover as planted forests, lower than the global average of 7%.

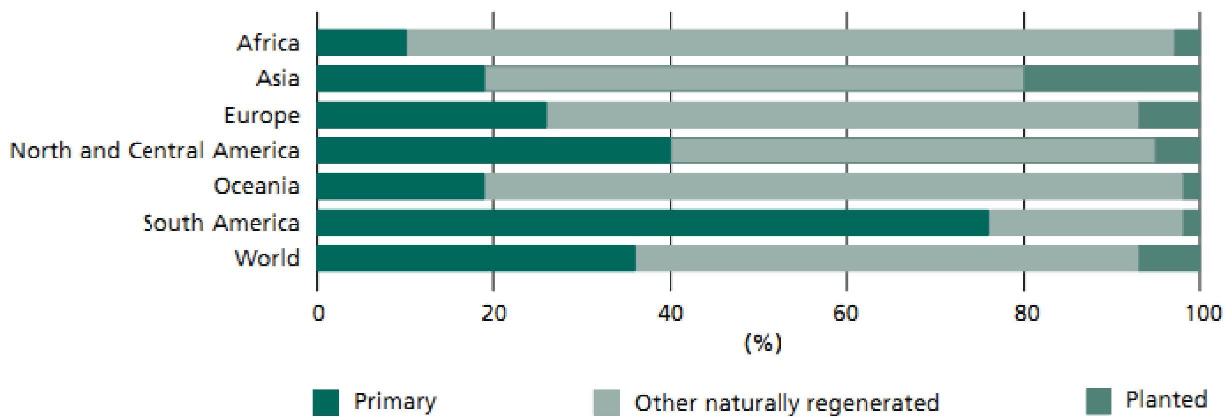

Figure 1. Characteristics of world forest 2010 (Source: FRA, 2010).

Figure 2 shows that there has been significant increase in the area of the planted forests, with the bulk of the area in Asia, rising from 75 million ha in 1990 to exceed 123 million ha by 2010. Africa has lagged behind in planting forests, rising from 12 million ha in 1990 to 16 million ha in 2010, averaging about 200 000 ha per year, compared to 2.4 million ha planted per year in Asia. In fact, as is evident in *Table 1* showing the extent of planted forest area, most of the additional plantation area in Africa is very recent, having been planted in the 5 years beginning 2006.

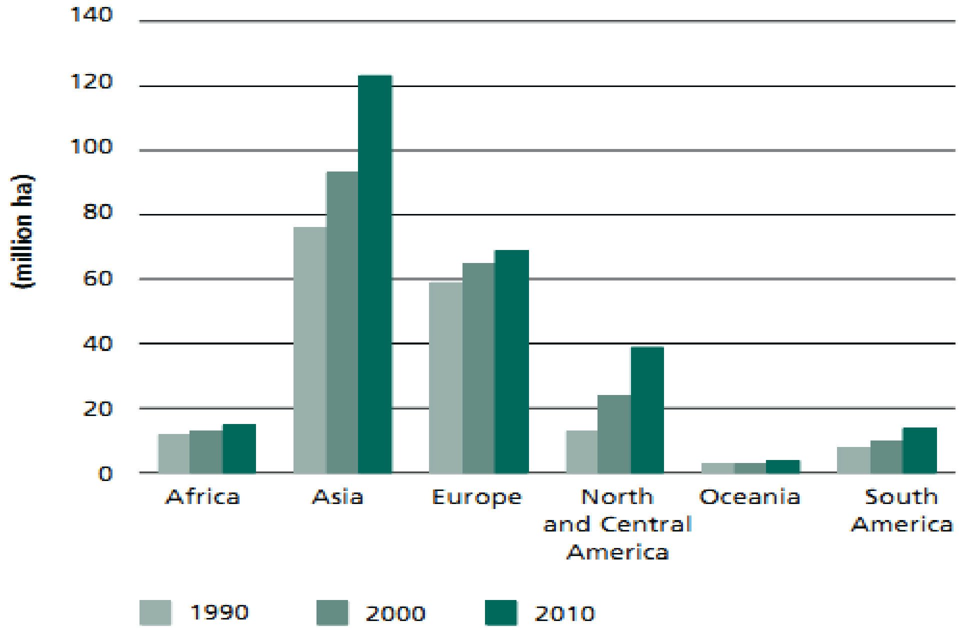

Figure 2. Change in extent of forest plantations 1990-2005 (FAO, 2010).

DEFORESTATION AND DEGRADATION IN PLANTATIONS

In forest plantations, a number of biotic and abiotic factors may cause loss of plantation area and/or degradation. Disturbance by biotic factors includes damage or loss due to insects and diseases, wildlife browsing, bark stripping, grazing or other physical damage by animals. In general, information on disturbances attributed to these factors is highly erratic and open to interpretation, with a broad range of causative agents. Specific problems reported from different countries include damage by possums, camels, beavers, antelopes, rodents (particularly squirrels and rats), lagomorphs (hares and rabbits), plus mites and nematodes (e.g. the pine wood nematode, *Bursaphelenchus xylophilus*) (FAO, 2010), as well as human encroachment and illegal harvesting.

Some of the planted tree ecosystems that are clearly prone to the impacts of both biotic and abiotic disturbances are the agricultural tree crop plantations such as rubber, wattle, oil palm, coconut, fruit and nut orchards, etc. For example, *table 2* below shows the significant area of rubber plantations in Africa, covering c. 680 000 ha by 2010.

Table 1: Change in extent of forest plantations 1990-2005 (FAO, 2010).

Country/area	Area of forest plantation (1 000 ha)			% of total forest area			Change rate (ha/year)	
	1990	2000	2005	1990	2000	2005	1990-2000	2000-2005
Angola	140	134	131	0.2	0.2	0.2	-562	-564
Comoros	2	2	1	16.7	25.0	26.6	0	-110
Kenya	238	212	202	6.4	5.9	5.7	-2 600	-2 000
Lesotho	4	6	7	88.0	91.4	92.5	200	200
Madagascar	293	293	293	2.1	2.2	2.3	0	0
Malawi	132	180	204	3.4	5.0	6.0	4 800	4 800
Mauritius	16	15	15	41.0	39.5	40.5	-100	0
Mayotte	n.s.	n.s.	n.s.	4.8	5.0	5.1	0	0
Mozambique	38	38	38	0.2	0.2	0.2	0	0
Réunion	5	5	5	6.0	6.0	6.0	0	-40
Seychelles	5	5	5	12.5	12.5	12.5	0	0
South Africa	1204	1 352	1 426	13.1	14.7	15.5	14 800	14 800
Swaziland	135	121	114	28.6	23.4	21.1	-1 400	-1 400
Uganda	33	35	36	0.7	0.9	1.0	200	200

Country/area	Area of forest plantation (1 000 ha)			% of total forest area			Change rate (ha/year)	
	1990	2000	2005	1990	2000	2005	1990-2000	2000-2005
Tanzania	150	150	150	0.4	0.4	0.4	0	0
Zambia	60	75	75	0.1	0.2	0.2	1 500	0
Zimbabwe	154	154	154	0.7	0.8	0.9	0	0
Total E and S Africa	2 609	2 777	2 856				16 838	15 886
Algeria	620	652	754	34.6	30.4	33.1	3 200	20 400
Burkina Faso	33	63	76	0.5	0.9	1.1	3 000	2 600
Chad	11	14	15	0.1	0.1	0.1	300	300
Egypt	44	59	67	100.0	100.0	100.0	1 500	1 600
Eritrea	10	22	28	0.6	1.4	1.8	1 200	1 160
Ethiopia	491	491	491	3.2	3.6	3.8	0	0
Libya	217	217	217	100.0	100.0	100.0	0	0
Mali	-	60	-	-	0.5	-	-	-
Mauritania	-	10	-	-	3.2	-	-	-
Morocco	478	523	563	11.1	12.1	12.9	4 500	8 000
Niger	-	72	110	-	5.5	8.7	-	7 500

Country/area	Area of forest plantation (1 000 ha)			% of total forest area			Change rate (ha/year)	
	1990	2000	2005	1990	2000	2005	1990-2000	2000-2005
Somalia	3	3	3	n.s	n.s	n.s	0	0
Sudan	6 111	5 639	5 404	8.0	8.0	8.0	-47 123	-47 123
Tunisia	226	423	498	35.1	44.1	47.2	19 700	15 000
Total N Africa	8 244	8 248	8 226				-13 723	9 437
Benin	98	109	114	3.0	4.1	4.8	1 100	1 000
Burundi	-	86	86	-	43.2	56.2	-	0
Cameroon	-	-	-	-	-	-	-	-
Cape Verde	58	82	84	100.0	100.0	100.0	2 435	300
Central African Rep.	2	4	5	n.s	n.s	n.s	230	200
Congo	51	51	51	0.2	0.2	0.2	0	0
Côte d'Ivoire	154	261	337	1.5	2.5	3.2	10 700	15 200
DR Congo	-	-	-	-	-	-	-	-
Equatorial Guinea	-	-	-	-	-	-	-	-
Gabon	36	36	36	0.2	0.2	0.2	0	0
Gambia	n.s	n.s	n.s	0.1	0.1	0.1	0	0

Country/area	Area of forest plantation (1 000 ha)			% of total forest area			Change rate (ha/year)	
	1990	2000	2005	1990	2000	2005	1990-2000	2000-2005
Ghana	50	60	160	0.7	1.0	2.9	1 000	20 000
Guinea	17	22	33	0.2	0.3	0.5	546	2 040
Guinea-Bissau	n.s	n.s	1	n.s	n.s	n.s	15	34
Liberia	8	8	8	0.2	0.2	0.3	0	0
Nigeria	251	316	349	1.5	2.4	3.1	6 500	6 600
Rwanda	248	282	419	78.0	82.1	87.2	3 450	27 220
Senegal	205	306	365	2.2	3.4	4.2	10 100	11 800
Sierra Leone	2	3	3	0.1	0.1	0.1	60	80
Togo	24	34	38	3.5	7.0	9.8	1 00	800
Total W and C Africa	1 204	1 660	2 089				37 136	85 274
Total Africa	12 057	12 685	13 171				62 800	48 600

Table 2. Trends in area of rubber plantations by country and region, 1990-2010 (FAO, 2010).

Style Table Header	Area of rubber plantations (1 000 ha)			
	1990	2000	2005	2010
Cameroon	39	43	49	52
Central African Republic	1	1	1	1
Congo	2	2	2	2
Côte d'Ivoire	60	84	120	120
Democratic Republic of the Congo	41	19	15	15
Ethiopia	1	1	1	1
Gabon	13	13	13	13
Ghana	11	17	17	17
Guinea	1	4	6	6
Liberia	109	109	109	109
Malawi	2	2	2	2
Nigeria	223	319	339	340
Sierra Leone	2	2	2	2
Zambia	0	n.s.	n.s.	1
Total Africa	506	615	676	680

Abiotic disturbances, including climatic events such as storms, drought, fire, snow, ice and floods, have always influenced forest ecosystems. However, global climate change and increased climate variability are reportedly making forest ecosystems more prone to damage by altering the frequency, intensity and timing of fire events, hurricanes, storms, landslides, and insect and disease outbreaks. Climate-related shifts in the range of pest species, many of which are forest-dependent, may further exacerbate abiotic impacts on plantation health since, in most cases, the trees would have been earlier weakened by the biotic factors.

Table 3. Loss of forest plantations in Africa from 1990 – 2005 (FAO, 2005).

Country	Area of forest plantations (1000 ha)			Change rate (ha/year)	
	1990	2000	2005	1990-2000	2000-2005
Angola	140	134	131	-562	-564
Comoros	2	2	1	0	-110
Kenya	238	212	202	-2 600	-2 000
Mauritius	16	15	15	-100	0
Réunion	5	5	5	0	-40
Swaziland	135	121	114	-1 400	-1 400
Sudan	6 111	5 639	5 404	-47 123	-47 123
Total Africa	6 647	6 138	5 872	-51 785	-51 237

Several disturbance factors, such as illegal logging, encroachment, over-harvesting through illegal cutting, and other unsustainable management practices, are some common factors in deforestation and degradation of plantations. Usually, normal harvesting of timber in plantations is accompanied by replanting or coppicing and would therefore not qualify as actionable for REDD+.

Extracting data from *table 1*, the area of African plantations that were lost between 1990 and 2005 is obtained. The summary presented in *table 3* above shows an annual loss of plantations averaging over 51 000 hectares with Sudan showing the lion's share of loss of plantations. This value is the equivalent to deforestation in natural forests. It is, however, important to point out that the statistics on forest plantations in Sudan include vast areas of managed, but naturally regenerated, gardens of *Acacia senegal* (gum Arabic) – the management of these favours trees of the same size and removal of other trees, thus creating a visual impression of even-aged mono-culture plantations.

In Africa, fires often constitute the single largest cause of deforestation and degradation of plantations. While some forest ecosystems depend on fire for their regeneration, in others it can be devastating and also frequently cause loss of property and human life, with plantations falling in the latter category. On average, 1% of all forests were reported to be significantly affected each year by fires (FAO, 2010 OP. CIT.). However, in general the area of forest affected by fires has been severely underreported, especially in Africa. FAO (2010) reports that less than 10% of all forest fires are prescribed burning; the rest are classified as wildfires.

Table 4. Average area of forest annually affected by fire by region and subregion (FAO, 2005).

Region/Sub-region	Information availability		Area of forest affected by fire	
	Number of countries	% of total forest area	1 000 ha	% of forest area
Eastern and southern Africa	8	29.3	452	0.6
Northern Africa	5	10.0	17	0.2
Western and Central Africa	8	19.7	7 849	11.9
Total Africa	21	22.4	8 318	5.4

Instances of fires in plantations are unlikely to exceed those in natural forests and the probability of destroying very large areas is small due to the intensive management of plantations, which include fire protection, robust fire-fighting capabilities, and road systems that act as fire breaks. If plantations were affected by fires at the same frequency as natural forests – a likely proposition since most of the fires are lightning caused – then, projecting from *table 4* above, this would imply that an estimated 5.4% of the area of African plantations would have been affected, adding up to about 870 000 ha. However, since there are fire protection and management programmes in the plantations, a much smaller area is damaged.

To obtain an estimate of area lost and degraded by fires, it is therefore assumed that the reported 51 000 ha of plantations lost annually include what is lost to fires. What can be confidently concluded is that a large portion of the 870 000 ha are left in different states of degradation, the extent of which is difficult to discern for lack of data. Assuming that the plantation fire management regime saves 3 out of every 4 ha projected to be affected by fires, then a working estimate of about 200 000 ha of degraded plantations and 51 000 ha totally lost to fires and other disturbances can serve as a preliminary estimate of the extent of forest plantation areas degraded and deforested.

Lacking reliable data on the extent of degradation, it is hereby assumed that there is a range in the rate of degradation, from complete destruction (commonly referred to as deforestation), through severe, moderate to minor degradation. It is reasonable to assume that total deforestation leads to the loss of all carbon (assuming that in the absence of replanting, the gain in soil carbon would also be lost in a few years depending on the process of deforestation), whereas moderate to severe degradation may be equivalent to losing half the above-ground carbon stock (assuming remaining vegetation will recover).

The loss of 50% of the aboveground carbon stock from 200 000 ha of degraded plantations can also be estimated by looking at the species used and their growth characteristics. For example, Good Practice Guidance (IPCC, 2003) gives a range of estimated annual gain of carbon stock in various plantations. Table 5 below shows the rates of carbon gain per year for eucalyptus and pine plantations, contrasting them with carbon gain in natural forests under different landscape potency classifications.

In general, African tree plantations are more efficient in sequestering carbon than natural forests in the same ecological zone because the species used for plantation establishment are usually fast growing and selected for their superior ability to produce biomass compared to natural forests. Similarly, the silviculture and management of plantations – including establishment, spacing and treatments - will favour higher carbon stock accumulation than natural forests. For example, some Eucalyptus spp. above 20 years old can produce 18 times more biomass per year than natural forests of similar age in a moist, short dry season climate (*Table 5*). Even in dry areas, Eucalyptus does accumulate 8 times more carbon per year than natural forests in the same provenance.

Table 5. Average annual carbon sequestration in aboveground biomass for natural forests and plantations by ecological category (t C/ha/y). (MERCER ET AL., 2011).

Type of vegetation	Years	Wet	Moist short dry season	Most long dry season	Dry	Mountain moist	Mountain dry
Natural forest	≤ 20	5.0	2.7	1.2	0.6	2.5	1
	> 20	1.5	0.7	0.9	0.5	0.5	0.8
Eucalyptus plantation	≤ 20	-	10.0	6.3	2.8	-	-
	> 20	-	12.5	-	4	-	-
Pine plantation	≤ 20	9.0	6.0	4	1.7	-	-
	> 20	-	7.5	5.5	1.3	-	-

In establishing a baseline for plantations, it should be borne in mind is that most production plantations are managed in approximately sustainable rotations, in which case at any point in time it can be assumed that there exists only half of the maximum carbon stock on site, and that this is the maximum avoided emissions from deforestation and the avoided emissions from degradation of the above ground biomass. However, in an actual REDD+ programme, the avoided emissions will have to take account of the age structure of the plantations in the country since, in many cases, the bulk of the plantations are young due to the accelerated rate of afforestation and reforestation as shown in Table 1 above.

Although 18 of the total 22 REDD readiness activities in the world were in Africa (MBOW ET AL., 2012), it is noteworthy from the point of view of this study that none of these activities was a REDD+ project specific for a forest plantation or for other tree crops. The literature does not show a single REDD+ project implemented in forest plantations anywhere in the world.

STEPS TO AVERT DEFORESTATION AND DEGRADATION OF PLANTATIONS

Including plantations in REDD+ activities and programmes would require intervening to avert or reduce the process of plantation loss and/or degradation, including but not limited to fire prevention and protection, stopping illegal harvesting and encroachment into plantations, and prevention of pest, disease and animal damage. Given the existence of active plantation management, and assuming that resources were the limiting factor, it should not be difficult to implement a REDD+ programme in plantation areas. The cost of such interventions should be weighed against the compensation from the REDD+ programme.

CARBON BENEFITS FROM REDD+ IN PLANTATIONS

Forest plantations may play an additional role in REDD+ programmes, e.g. where reduction of emissions from deforestation of natural forests involves establishing plantations or woodlots to supply products in lieu of obtaining them from the natural forests. A common reason for establishing such plantations in Africa are the woodlots established to provide wood-fuel instead of harvesting it from natural woodlands.

The carbon benefits for REDD+ in plantations depend on the baseline established. Since plantations are normally established for either of the purposes protection (e.g. wind-breaks), production (e.g. for timber) or for carbon sequestration, the baseline would constitute an assumed continued deforestation and degradation of the plantation. Thus, in areas of remaining plantations that were not deforested or degraded, the total carbon gain would be made up of two components:

1) carbon gained from avoided loss of forest area which would constitute the difference between the stock on an intact hectare and the carbon stock on the depleted hectare;
2) the carbon gain from the avoided degradation will also constitute the difference between the stock on an intact hectare and that on the degraded hectare. This assumes no possibility of recovery or existence of persistent disturbance. However, it is unlikely that the baseline for degraded plantation would continue to be the same level of degradation without some sort of recovery. Since the process of degradation has been on-going for some years, the baseline for the degradation could be obtained from measuring the carbon stock in different areas in various status of recovery. As a first approximation, it can be assumed that up until the intended rotation age, the recovery would not have been completed and, as such, the carbon benefit would be the difference between the carbon on an intact hectare and that on the semi recovered hectare.

To be on safer ground when establishing baseline values, some degraded and deforested areas could be left without any intervention so that they can be used as control plots to obtain actual carbon gained from the REDD+ intervention.

Given the partial recovery expected, and given the conditions for current CDM Afforestation and Reforestation projects in compelling a baseline that uses non-forested land with minimal carbon stock, it stands to reason that the carbon benefits for REDD+ in plantations will be less than that in CDM per ha and even more so than REDD+ benefits from conserving natural forests. If the vast majority of African plantations are for production, regaining the carbon on the 51 000 ha annually lost is not trivial, neither that on the estimated 200 000 ha of degraded plantations.

Many African plantations use fast-growing exotic species (mainly eucalypts and pines), sometimes called 'fast woods', which can produce yields of up to 20 t/ha/y of timber (SPGS, 2004; Chamshama and Nwonwu, 2004) compared to around 2 t/ha/y in logged over rain forests. Average harvesting cycles (rotations) in plantations depend on the tree species used, the final product and the timber market. Some eucalyptus plantations produce small wooden poles (for scaffolding, small construction timber, low quality furniture, etc.) in as little as 3 years, but take 30 years to grow large, high quality timber for sawnwood. Pine species take 12–20 years for pulp, and 30-45 years for sawnwood (SPGS, 2004). As shown in Table 5 above, annual carbon sequestration can be quite high and the total carbon stock is also high, especially for moist ecosystems (*Table 6*).

Table 6. Average aboveground carbon stored in natural forests and plantations by ecological category in tropical Africa (t C/ha). (Mercer et al., 2011).

Type of vegetation	Years	Wet	Moist short dry season	Most long dry season	Dry	Mountain moist	Mountain dry
Natural forest	≤ 20	160	130	62	36	146	20
	> 20	65-256	80-217	60-65	8-98		
Plantations broadleaf	≤ 20	50	40	15	10	50	20
	> 20	150	75	35	10	75	30
Pine plantation	≤ 20	30	20	10	8	20	5
	> 20	100	60	30	10	50	15

To get an idea of the carbon magnitudes involved, we assume that the average stocking is represented by that of young Eucalyptus planted in a moist area but with a long dry season – characteristic of lands available for plantation establishment. With an above ground biomass growth of 6.3 tons of carbon (tC) per ha and year, and using a conversion ratio of 1.6 to obtain total carbon (i.e. including below ground growth), we get an average of 10 tC/ha/y. Assuming that the deforested plantations are managed in sustainable rotations, then the creditable amount of carbon would be half of the carrying capacity of the area, that is 5 tC/ha/y. Assuming an average plantation age of 12 years (given the age structure of most recent African plantations), then the total creditable carbon benefits would be 60 tC/ha deforested that is equivalent to 220 tonnes of CO_2/ha. Summed over the 51 000 ha deforested we obtain over 11 million tCO_2/y.

The emission reduction from degradation, given the assumptions made in section 2.4 above, is equivalent to loosing half the aboveground carbon (3.15 tC /ha/y) over the 12 year average age, adding up to 38 tC/ha. Summed across the degraded 220 000 ha it is estimated that an emission reductions of c. 8.3 million tC/y can be obtained from plantations, i.e. c. 30.5 million tCO_2 from degradation.

Using this simplified exemplification, the estimated amount of emission creditable to REDD+ in African plantations exceed 40 million tCO_2/y, the market value of which will be in the hundreds of millions of dollars depending on the carbon market.

Other benefits accruing from this intervention is to ensure the supply of the products that were intended at the time of establishing the plantation, the alternative to which would either come from natural forests, from over-harvesting in the plantations, or from imports. Failure to replace the lost wood products would result in an upward pressure on prices due to the supply shortage.

ADVANTAGES OF PLANTATION REDD+ ON COMMUNITY ISSUES.

Some of the contentious issues arising from REDD+ programmes in natural forests involve the rights of the users of goods and services in the pre-REDD+ forest situation and the right of access to protected forests, as well as how to ensure that benefits from the carbon gain reach the communities that were using the forests (BAGINSKI AND WOLLENBERG, 2010). The African socio-political context sometimes constitutes a dilemma for REDD+ because recommended mechanisms and provisions on how to implement REDD+ programmes, and related literature, contain some aspects that are incompatible with prevailing social and political organisation within some African communities. Among such controversial recommendations are the implementation of Western notions of property rights, improved governance, local participation, and sustainable development (MANTLANA, 2010).

The primary challenge in this regard is land tenure. The prevailing land tenure context on the continent is characterised by overlap and the co-existence of various land tenure forms which simultaneously allocate to the state, the community, and the individual incongruous and various levels of legal title to land, and the resources thereon. This situation is incompatible with the conventional concept of property rights and causes contestation between the state, local/traditional government and individuals for benefits from "community development".

These issues do not arise as much in the case of plantation REDD+ because most plantations in Africa are owned by the private sector, the state, or by a known community or individual, without the ambiguity of tenure in natural forest areas. However, as was discussed in section 2.4 above, it is clear that some deforestation is caused by community members proximal to plantations seeking timber, firewood, grazing land and agricultural land, in some cases while still harbouring notions of rights and access to the area that existed before it was converted to a plantation. Distribution of part of the carbon benefits to adjacent communities and/or individuals as a compensation for lost uses may be worthy of consideration, even though some of their prior activities also were illegal to an extent, particularly where no prior and acknowledged community tenure arrangements were in place. It is worth noting that unless some of their needs are creatively met, there will be leakage such that they shift their activities to natural forests and therefore reducing or eliminating the carbon benefits, or/and the plantation REDD+ programme will be very expensive to implement.

OTHER MITIGATION ACTIVITIES FROM PLANTATIONS

This report also seeks to examine other relevant mitigation activities in plantations in Africa and assessing their potential for up-scaling. The Kyoto Protocol (KP) brought in afforestation and reforestation projects, including agroforestry, and later also efficiency in biomass utilisation into mitigation efforts. These options remain the most potent mitigation activities in the forestry sector and have been strengthened by the Copenhagen Accord that introduced Nationally Appropriate Mitigation Activities (NAMAs), which allow for programme/policy architecture in lieu of the KP straight jacket of project architecture. This expansion of the scope of emission reduction activities does include the indirect use of plantations for mitigation.

Activities that come under consideration here include two components described below.

- Plantation forestry to reduce pressure on natural forests as a REDD+ programme unto itself. The bulk of biomass produced in tropical forests is used to meet domestic demand. For example, 80% of all timber harvested in DRC is for domestic consumption (DJIRÉ, 2003). New or expanded plantation forestry intended to wean African countries from overdependence on timber and woodfuel from natural forests may reduce emissions from deforestation and degradation of natural forests. It is estimated that the superior efficiency of plantations for biomass production need to utilise less than 20% of the area of natural forests to meet the same wood demand in Africa (MERCER ET AL., 2011).
- Biomass co-generation of energy can contribute in reducing dependence on oil imports and associated emissions. Many African economies are growing at a fast pace and their demand for electricity is growing even faster. Power production in Africa is moderately to highly dependent on fossils fuel. Combined heat and power technologies can be used to generate power from the large amounts of wood waste from the wood industry (see Box 1). The carbon benefit from increased cogeneration will depend on the current proportion of fossil fuels in the country’s energy mix, with the more fossil fuel dependent countries, such as South Africa, obtaining higher carbon benefits.

Box 1. Cogeneration in wood industries (Makundi, 2010).

For example, Tanzania has estimated forest residues amounting to 1.1 million t/y. The company Green Resources has proposed a 15MW electricity biomass-fired cogeneration project at Sao Hill where the raw material is residues from the sustainably managed plantations and the wood waste from the Sao Hill Industries. The steam will be used for thermal processes such as dry kilns and a portion of the electricity generated will be used to operate the sawmill, with the excess (~10MW) sold off to the national grid and nearby local industries and tea estates. The annual projected revenues from electricity sales are about $9.1 million, with carbon credit revenues of $1.3 million, a project with 18% pretax IRR from an initial investment of $26.5 million.

In addition to being the feedstock for pulp and paper production, biomass is also a major energy resource for the plant. Black liquor and solid-biomass residues (bark and hog fuel) generated at the mill is also used for energy. The industry also has access to residues from pulpwood harvesting, some of which can be removed from the forest on a sustainable basis. All black liquor and most mill residues are used at mill sites to fuel cogeneration systems, providing steam and electricity for on-site use. For example, Mufindi Paper Mills at Mgololo in Southern Tanzania, generates about 40MW from wood residues. The energy is used in running paper-making machinery.

Tanzania Wattle industry in Njombe generates about 2.5 MW from wattle plantation residues fed into the national grid. The industry is planning to generate 15 MW and sell to the national grid. Research has established that 2.4 kg of wattle fire wood can generate 1kWh of electricity.

Many sawmills and wood industries across the African continent, using wood from plantations and natural forests, can utilise the CDM and NAMAs windows to significantly reduce emissions, with additional carbon revenues in tow, e.g. through:

- efficient woodfuel stoves using plantation based biomass as fuel can generate emission reductions commensurate to the increased efficiency;
- production and use of liquid bio-fuels from bioenergy tree plantations to supplement the use of fossil fuels for transportation can play a significant GHG mitigation role. This will also generate significant bio-waste as a potential contribution to co-generation of energy. It is noteworthy that, so far, biofuel initiatives in Africa have met with important challenges, such as weak production and distribution infrastructure, low productivity on marginal lands, competition for land with agriculture and grazing, and land conflicts arising from unclear or weak tenure arrangements prior to biofuel investments.

Much of the pulp and paper production in Africa is based on wood from plantations. This industry offers significant opportunities for emission reduction through energy conservation and efficiency improvements. Pulp, paper and particle board mills account for a significant part of the energy used in the total manufacturing industry in Africa. Given the low income and development levels of the continent, paper per capita demand is still low but rising rapidly. Wood for pulping represents the largest cost among material inputs to the pulp and paper industry, but also the energy cost of the industry is significant. An increasing portion of the energy requirements come from self-generated biomass sources.

Pulp and paper mills are often large and complex facilities that may produce several pulp and paper qualities from both softwood and hardwood raw material. Electricity is used for many processes, including pumping, air-handling and lighting. In addition, steam needs and the large number of heat-requiring processes makes the industry a good candidate for improved heat integration. Information technology - sensors, computers, control systems, etc. - is developing rapidly and offers a potential for higher product quality and lower energy use.

Concentrated black liquor from kraft pulping is burned in recovery boilers to both recover process chemicals and generate steam. The chemical recovery system is thus an integral part of the process, with a capital cost of about one-sixth of the total cost for a new bleached kraft pulp mill.

Adopting the new technologies of biomass and black liquor gasification, along with combined cycle cogeneration systems, could make the paper and pulp industry much more energy efficient and self-sufficient, while reducing GHG emissions significantly.

CHAPTER 3 Conclusions and recommendations

The study was done under the AFF "African forests, people and climate change" project that seeks to develop the nexus between forests and climate change in the major African forest and woodland ecosystems. This report presents the results on an examination of the prospects of mitigating climate change in plantations, with a focus on the prospects of Reducing Emissions from Deforestation and Degradation (REDD+) in plantations. Globally, tree plantations occupy about 20% of all forest cover, with Africa's 16 million ha constituting only 4% of its forest cover, lower than the global average of 7%. The pace of planting in Africa has accelerated in the last decade. Any ecosystem of this magnitude is bound to be affected by the forces of deforestation and degradation, and Africa is no exception.

It is estimated that African forest plantations are losing about 51 000 ha to deforestation every year and another 200 000 ha of plantations are under different stages of degradation annually.

It is recommended that forest plantations be included in REDD+ efforts in the forestry sector. If fully utilised, forest plantations could spur about 40 million tCO_2 from plantations creditable to REDD+ annually. Under a \$10/t of CO_2 price estimate for carbon, such emission reduction would earn the African forest sector an additional \$400 million annually to be ploughed into plantation forest management.

More mitigation options in the plantation forestry should be pursued, especially under the category of Nationally Appropriate Mitigation Activities. These actions may include biomass conservation, utilisation efficiency improvements, use of plantation and wood industry residues for co-generation of heat and power, complimentary possibilities to establish new plantations for the production of biofuels, as long as it does not impinge on food security and exacerbate land conflicts where the resource is scarce. It is also recommended that African countries consider expansion of plantations as a REDD+ programme to relieve pressure on natural forests.

It is thus recommended that African countries involve plantations in climate change baseline studies and include MRV issues in the regular plantation management plans.

To allow for meaningful participation of plantations in GHG mitigation, African countries should foment the policy and institutional changes necessary within the forest management system.

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