CLIMATE CHANGE AND SUSTAINABLE RENEWABLE NATURAL RESOURCES MANAGEMENT

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CLIMATE CHANGE MITIGATION AND THE FOREST SECTOR

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Abstract

The paper provides an overview on the global phenomenon of climate change and the portentous impacts of greenhouse gas (GHG) emission. The international efforts vis-à-vis the UNFCCC and the Kyoto protocol aimed at curbing the effects of climate change were discussed. The role of the forest as a potential climate change mitigation tool was also analyzed while policies for mitigation were appraised. Forests and vegetation cover are seen as an important source of carbon as well as a carbon store. Thus, they can play a key role in generating carbon offsets- the most important GHG being contributed by human activities. The conservation of forests offers important opportunities to mitigate climate change and protect biodiversity. Therefore, the impacts of climate change on human and natural ecosystems can be reduced through the adoption of forest-based conservation strategies. The paper concludes by drawing lessons applicable to tropical African countries.

Keywords: Climate change mitigation, green house gases, UNFCCC, Kyoto protocol, carbon Sequestration, forest management and conservation

Introduction

The global phenomenon of climate change is one of the most significant challenges facing humanity in the twenty first century. At present, the earth appears to be facing a rapid warming, which most scientists believe results, at least in part from human activities (Hart, 2006; Ehrenfield, 2005; Rosenbaum et al., 2004). Although, the mechanism of global climate give some indications of the complexity of the overall system of the earth, human activities have continued to cause distruption to the dynamics of the earth's natural cycles. The burning of fossil fuels and deforestation add Carbon (iv) oxide (CO_2) and other greenhouse gases (GHGs) to the atmosphere. Many human systems are already being affected, particularly, agriculture, water resources, industry and human health (Mc Carthy *et al.*, 2001).

Over the years, sustainable management of tropical forest resources has been of primary concern due to its potential implication on biological diversity and importance in maintaining global ecological functions. Essentially, forest ecosystems are an important consideration in the development of climate change mitigation strategies because they can both be sources and sinks of GHGs (DiNicola *et al.*, 1997). Meanwhile, the world's forests are estimated to be a net carbon source, primarily because of deforestation and forest degradation in the tropics. Although, in the past, developed countries have taken advantage of tropical genetic resources to improve their construction, agricultural and pharmaceutical industries, at little or no cost. Nevertheless, temperate and boreal forests are a carbon sink because many are recovering from past natural and human disturbances and are actively managed.

Besides, industrialized countries are already dedicating significant resources to protect themselves against the impact of climate change. Unfortunately, the poorest countries, which have contributed least to GHGs emissions, are usually the most vulnerable to climate change. Most rural people who are among the poorest in the world, are not only located in high-risk areas, but their lack of economic and social resources mean they are ill equipped to adjust to the long-term changes in climate. Indeed, ecologically sensitive zones in Africa are among the world's most vulnerable areas. The population of Africa is relatively vulnerable to damages wrought by climate change due to its high dependence on natural systems for daily survival. Hence, African countries should participate actively in identifying potential for greenhouse gas abatement. The risks of climate change for least developed countries are hard to predict, and communities, governments and other institutions in these countries must prepare in order to reduce and minimize the adverse effects.

To control GHG-induced climate change, it is important to curb GHG sources and enhance carbon sinks on a global scale. Forests and vegetation cover are an important source of carbon as well as a carbon store. This means they can play a key role in generating carbon offsets- the most important GHG being contributed by human activities. The conservation of forests offers important opportunities to mitigate climate change and protect biodiversity. Therefore, the impacts of climate change on human and natural ecosystems can be reduced through the adoption of forest-based conservation strategies. Since the world is now a global community, the industrialized nations have a role to play in helping developing countries cope with the vagaries of climate change through the adoption of forest-based options.

Climate Change: An Over View

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (Inter-governmental Panel on Climate Change, 2001). The definition given by the UN Framework Convention on Climate Change (UNFCCC) refers to it as a change of climate that is attributed directly or indirectly to human activity which alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC, 2006). The term- climate change is often time simplistically equated with "global warming", and the two have been used synonymously in the literatures. Whereas, climate change is a long-term alteration in global weather patterns, while global warming which is due to increases in temperature and storm activities, is regarded as potential consequence of the rise in green house effect.

Green house gases (GHGs) occur naturally in the environment and also result from human activities. It comprises of water vapour, carbon (iv) oxide gas (Co_2), methane, nitrous oxide, ozone and Hydro Fluro Carbons (HFCs). A newly identified member of the GHGs is Trifluoromethyl sulfur pentafluoride (Hart, 2006). The GHGs play a key role in the earth's climate. For instance, energy from the sun that passes through the atmosphere warms the surface of the earth. Some of that energy radiates back towards space from the surface as infrared light. GHGs absorb or reradiate the infrared light, preventing the energy from traveling out into space, thereby trapping heat-a phenomenon referred to as "green house" effect. Without GHGs, the planet would be too cold to sustain its current life. Ice would cover the earth from pole to pole. In fact, the planet would be colder by about 33°C as against its current average surface temperature of 15°C (Hart, *op.cit.*). However, increases in GHG levels result in the planet growing warmer and thus giving rise to the global warming phenomenon. The chief cause of global warming nay climate change is thought to be the burning of fossil fuels, such as coal, oil, and natural gas, which releases into the atmosphere the various components of the greenhouse gases (GHGs) most especially CO_2 In addition, deforestation, industrial and farming activities and various degrees of land use changes also contribute significantly to the release of green house gases into the atmosphere. Thus, while the current concentration of CO_2 in the atmosphere, 370 parts per million (ppm), is about 35 percent higher than it was in pre-industrial times (280 ppm), industries worldwide now add about 6.3 gigatonnes of carbon as CO_2 to the atmosphere each year (Rosenbaum *et al*, 2004). Consequently, the average global temperature has increased by about 0.6°C and a rise in the global mean sea level of between 10 to 20 cm. (IPCC, 2001).

Effects of Climate Change

The impacts of climate change cut across all regions of the world. From the polar region to the forest land through series of marine and coastal ecosystems, the impacts are pervasive and quite alarming. Various scientific reports have highlighted the negative impacts of the steady change in the global climate (UNFCCC, 2006; IPCC, 2001). The Arctic is already warming twice as fast as the global average. Deserts are projected to become hotter and drier. Forests could become more vulnerable to invasive species as a result of increasing threat by pests and fires. Potential impacts of climate change on marine and coastal ecosystems have been identified to include increased coastal erosion, more extensive coastal flooding, higher storm surge, landward intrusion of seawater in estuaries and aquifers, higher sea-surface temperatures, and reduced sea-ice cover.

All these changes pose debilitating effects on both biodiversity and human systems. For instance, the recently extinct golden toad and Monteverde harlequin frog have already been labeled as the first victims of climate change. Moreover, current climate change has already made "refugees" of two communities. The Lateu settlement, located in the Pacific island chain of Vanuatu, and the Shishmaref village, located on a small island in Alaska, were recently relocated the former to escape rising sea levels, the latter degrading permafrost as a result of climate change impacts (Secretariat of the Convention on Biological Diversity, 2007).

Many human systems are susceptible to climate changes, particularly, forestry, agricul ure, water resources, industry and human health. The impacts of climate change are expected to ha ve varying consequences for the availability of freshwater around the world. By 2025, it is pro ected that around 480 million of people in Africa will face either water scarcity or stress with a ubsequent potential increase of water conflicts. The health effects are overwhelmingly negative. Cholera, associated with both floods and droughts, may increase with climate change, whi e increased flooding could facilitate the breeding of malaria carriers.

In the agricultural sector, climate change will lead to reduction in soil fertility; changes in the availability of feed and fodder; decreased livestock productivity; increased incid nce of pest attacks and the manifestation of vector and vector born diseases. Similarly, heat stress and drought are likely to have a negative impact on animal health, production of dairy products, meat and reproduction (SCBD, 2007). This in turn could impact on food security leading to protein deficiency and malnutrition (Mc Carthy *et al.*, 2001). The food security threat posed by climate change is particularly great for Africa, where agricultural yields and per capita food production have been steadily declining, and where population growth will double the demand for food, water and forage in the next few years. In fact, the current lingering global food crisis lends credence to the above position.

International Efforts Aimed at Controlling Climate Change

The international community response to the global phenomenon of climate change comes under the United Nations Framework Convention on Climate Change (UNFCCC). The convention was signed at the UN Conference on Environment and Development (the popular Rio summit) in 1992. Essentially, the aim of the agreement is to stabilize atmospheric concentrations of greenhouse gases at levels that will prevent human activities from interfering dangerously with the global climate system. However, while the convention sets goals and objectives and outlines basic mechanisms for the climate change regime, it lacks many specifics, in particular quantified GHG reduction obligations. In response to the defects of the convention, the Kyōto Protocol, an international treaty that sets concrete targets for developed countries to reduce the greenhouse gas emissions that contribute to global warming was adopted in 1997. The Kyōto Protocol is a supplementary treaty to the United Nations Framework Convention on Climate Change (UNFCCC) and went into force in February 2005. More than 130 countries are party to it. However, the United States, which is the largest emitter of GHGs (36% of 1990 emissions), has refused to ratify the treaty.

Under the Kyōto Protocol, nonetheless, developed or industrialized countries are subject to legally binding commitments to curb their emissions of the six main greenhouse gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The targets are based mostly on the emission levels of these pollutants in 1990. In general, the treaty calls for industrialized nations to reduce their greenhouse gas emissions by 5 percent below 1990 levels. The target goals must be accomplished by 2012, and commitments to start achieving the targets begin in 2008. Developing countriesthat is, most countries in Africa, Asia, and Latin Americaare only subject to general commitments.

The Kyōto Protocol is a flexible treaty, allowing individual governments to decide what specific policies and reforms to implement to meet their commitments. It also allows countries to offset some of their emissions by increasing the carbon dioxide absorbed, or sequestered by trees and other vegetation. However, eligible sequestration activities, and the amount of offsetting allowed, are tightly controlled.

The Kyoto Protocol and the Adopted Mechanisms to Reduce GHG Emissions

The Kyoto Protocol provides several mechanisms that could be used to reduce GHG emissions to meet the reduction targets. In this section, these mechanisms are briefly described following

UNDP's Sustainable Energy and Environment Division (SEED-UNDP, 2000) with a view to clarifying differences between the mechanisms.

The Clean Development Mechanism (CDM) (Article 12)

It is the ultimate product of a proposal made by Brazil. That proposal suggested elements for inclusion in a Protocol or other legal instrument that would strengthen the emission reduction commitments of Annex I Parties to the Convention, as contained in Article 4.2 (a) and (b) of the Convention. The Clean Development Mechanism (CDM) as defined by the Kyoto Protocol, holds the potential to assist non-Annex I Parties in achieving sustainable development, while contributing to the ultimate objective of the UNFCCC-stabilizing greenhouse gas levels in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Its potential future operation is based on an incentive structure directly linked to the Annex I Parties' fulfillment of their quantified commitments under the Protocol. Developing countries do not have such commitments, but may, through the CDM, participate actively in the international effort aimed at combating global climate change.

The CDM is an important potential instrument for promoting international cooperation (e.g. through foreign investment in the energy sector) and simultaneously addressing the issue of sustainable human development. The objectives of the CDM, as specified by article 12 of the Kyoto Protocol, are:

- assisting Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention; and

- assisting Annex I Parties in achieving compliance with their quantified emission limitation and reduction commitments under Article 3.

Benefits to developing countries will come through investment in cleaner development paths. The benefits to industrialized countries will stem from contributing to reducing emissions at a lower cost than would be the case through domestic action only. In order for the CDM to form a basis for Certified Emission Reductions Units (CERUs), ways of incorporating CDM project activities into developing countries' priorities for development must be taken as the point of departure.

Ideally, the CDM will induce additional capital flows to developing countries, accelerate technology transfer, and enable developing countries to leapfrog to cleaner technologies, while helping developed countries achieve their emission reduction commitments at lower costs. The size of the CDM market will be influenced by a number of dynamic variables. These include: the total size of the global market for carbon credits, the rate of growth in Annex I emissions, the amount and cost of domestic reductions, and the attractiveness of CDM CERUs vis-à-vis joint implementation and emissions trading. A strong financial incentive for firms to participate in the CDM could develop, because, compared to domestic action, the costs of Annex I compliance through CDM credits could, in general, be much lower.

Joint Implementation (Article 6)

Joint Implementation (JI) allows countries in Annex I to implement measures jointly to reduce their GHG emissions. As it concerns Annex I countries, it is an especially important mechanism for economies in transition. In order for a JI project to receive "emission reduction units", the activities must incorporate the sustainable development priorities of economies in transition acting as host countries. For this reason, JI is a mechanism for facilitating the processes of socio-economic transition and sustainable development while implicitly benefiting the global environment. Accordingly, reductions in the growth of greenhouse gas emissions need to be accomplished through activities carried out to meet immediate objectives related to such issues as poverty alleviation, energy and resource utilization and infrastructural planning and development.

Emissions Trading (Article 17)

Emissions trading is a market-based instrument which uses "assigned amounts" to allow for trading between countries that have accepted emission reduction commitments under the Kyoto Protocol, as listed in its Annex I. Unlike the CDM and JI, emissions trading is not project-related. However, similar to CDM and JI, emissions trading enables achievement of commitments at least cost, by taking advantage of marginal cost differentials in emissions abatement among countries. Since greenhouse gases are uniformly mixing global pollutants, both the damages from emissions and the benefits from emission reduction are independent of their origins. In order to minimize the costs of global emission reductions, abatement should take place where the costs are lowest. Emissions trading could allow this to happen in an efficient and cost-effective manner. Modalities for emissions trading remain to be established.

Climate Change and the Forest Sector

The association between climate and forestry has been widely discussed in the literature (Nwoboshi, 1982; Amusa, 2002). For instance, many of the approaches to forestry, including provenance selection and silvicultural management are based on the long-standing knowledge of the relationships between climate and forest productivity. Consequently, there is great concern over the implications of a changing climate to the forestry industry, particularly since the species and provenances planted at present and in the recent past reflect the current climate. The forest sector (i.e., forestry and forest industry, including the use of forest land) plays an important role in the global climate change debate partly because the sector influences the global carbon cycle, and partly because the sector is influenced by possible global climate change caused by increased concentrations of greenhouse gases, among which CO_2 is the most important. It is now widely recognized that climate change is likely to have strong influences on the structure and function of forests (Watson et al., 2001, IPCC, 2007). These impacts can be categorized into three general areas viz: forest productivity changes, ecosystem disturbances, and changes in forest species distribution. Productivity changes are adjustments in the productivity of forests which alter the growth rates of forest species (in either a positive or negative way), while changes in disturbance influence the standing stock of timber and non-timber species through pest infestations, forest fires, wind-throw, and ice damage. Changes in species distribution result from shifts in climate, which ultimately alter the optimal geographic location of different species.

Meanwhile, climate change offers a potential for additional carbon in the atmosphere to enhance the growth of trees and other forest products (carbon fertilization effect). Boisvenue and Running (2006) reviewed historical trends in net primary productivity in forests and found that over the last 50 years most studies have reported increasing growth trends in forests where water is not a limiting factor. However, some studies have suggested that inter-annual variation in temperature and precipitation could have positive or negative effects on annual growth, depending on the direction of change (Tian et al., 1998; Schimel et al. 2000). Thus, carbon fertilization effects may be limited both by changes in annual weather or by other limiting nutrients (Melillo et al., 1993). Besides, carbon fertilization effect could reach a saturation point for some particular species and ecosystems (Gitay et al., 2001). Apart from this, some authors have suggested that climate change could lead to dieback in existing or future forests due to water stress, insect infestations, or fires (Solomon and Kirilenko, 1997; Bachelet et al., 2003; Bachelet et al, 2004; Scholze et al., 2006).

Nevertheless, current evidence suggests that climate change may already be causing more intense fires in some regions of the world (Westerling et al., 2006), and forests are particularly vulnerable to climate change because many forest-dwelling large animals, half of the large primates, and nearly 9% of all known tree species are already at some risk of extinction. Besides, climate change may force species to migrate or shift their ranges far faster than they are able to. Some species may die off as a result. Sohngen *et al* 2007 have captured succinctly, the ecological and economic implications of climate change on the forest sector (Table 1).

Table 1: Ecological and Economic Implications of Climate Change on the Forest

	Short-Term (2005 – 2025)	Medium-Term (2025 – 2065)	Long-Term (2065 – 2105)
Boreal	• ↑Risk of fire/natural disturbance • ↑Salvage; ↑Timber Supply.	•↕Productivity • ↑↑Risk of fire/natural disturbance • ↑Expansion of species northward • ↑Southern range displaced by more southerly forest types. • ↑Salvage; ↑Timber Supply	•↕Productivity • ↑↑Risk of fire/natural disturbance • ↑↑Expansion of species northward • ↑↑Southern range displaced by more southerly forest types. • ↑Salvage; ↑Timber Supply
Temperate	•↕Productivity, •↕Timber Supply, ↓Timber Prices	•↕Productivity. • ↑Risk of fire/natural disturbance • ↑Movement of species northward. • ↑Salvage; ↑Timber Supply	•↕Productivity. • ↑↑Risk of fire/natural disturbance • ↑Movement of species northward. • ↑Salvage; ↑Timber Supply
Tropical	•↕Productivity, • ↑Plantation establishment • ↑Timber supply to world market	•↕Productivity. • ↑Risk of fire/natural disturbance • ↑Risks to plantations and natural forests • ↑Salvage; ↑Timber Supply	•↕Productivity. • ↑↑Risk of fire/natural disturbance • ↑Risks to plantations and natural forests • ↑Salvage; ↑Timber Supply
World Market Effect	• ↑Supply from rising productivity and the possibility of salvage • ↓World Timber Prices •↕Producer welfare • ↑Consumer welfare	• ↑Supply from rising productivity due to and the possibility of salvage. • ↓World Timber Prices •↕Producer welfare • ↑Consumer welfare	• ↑Supply from rising productivity and the possibility of salvage. • ↓World Timber Prices •↕Producer welfare • ↑Consumer welfare

(?= increases in indicator; ?= decreases in indicator; ?= both increases and decreases in indicator likely; ?? stronger effects likely)

Forest as a Climate Change Mitigation Tool

The challenge of climate change mitigation and adaptation is managing the probable impacts while taking steps to prevent detrimental effects in the future There are two major approaches to achieving this. The first is to keep carbon dioxide out of the atmosphere by storing the gas or its carbon component somewhere else, a strategy called carbon sequestration. The second major approach is to reduce the production of greenhouse gases. The forests constitute a significant factor in carbon sequestration and also serve as a carbon sink through the living trees that store carbon iv oxide gas from the atmosphere using it in their process of photosynthesis.

Three classes of forest-related activity can affect GHG concentrations. The first is the establishment, enhancement or protection of forest ecosystems. Afforestation and reforestation of non-forested lands can increase, and prevention of deforestation can maintain, the amount of carbon held in forests. These are widely acknowledged as potential means of offsetting or reducing a part of anthropogenic GHG emissions. Their relatively low cost, compared with non-forest offset options, may make them economically attractive (Dayal, 2000). Besides, improved forest management can enhance existing forests to increase the carbon storage on site. For example, selective cutting schemes, lengthened rotations, reduced-impact logging, and species choice may achieve a higher average level of sequestered carbon.

The second activity relating to GHG concentrations within the forestry sector is the enhanced use of forest products. Using wood in buildings and other long-lived objects can effectively sequestered carbon for the life of the object. Substituting essentially carbon-neutral wood for energy-intensive materials such as brick, aluminium or steel may significantly reduce the use of fossil fuels, which of course release carbon iv oxide gas when burned.

The third activity is the sustainable production of wood fuel from forests, which can serve as alternative to fossil fuels. Although burning of biomass fuels releases carbon (iv) oxide gas, the re-growth of a sustainably managed forest offsets that release. Thus, forest fuels can supply energy virtually without net contribution to GHG levels.

However, for the forest sector to fulfill the above-mentioned potentials, two important instruments are required. These are: legal framework and economic tools. The full range of forest legislation in response to climate change is extremely important. For instance, the state of New South Wales in Australia has changed its property laws to recognize a separate legal interest in the carbon sequestration potential of forest land. The Dominican Republic has also adopted a law that will allow it to create incentives for managing forests for environmental services such as carbon sequestration. The list of other jurisdictions that have considered or adopted some sorts of forest-related climate laws includes the European Union, the Canada province of Alberta, Peru, Spain and Denmark (Rosenbaum *et al.*, 2004).

Other legal measures could center on forest use and management. Forest use and management could be regulated by specifying permissible logging techniques, prompt reforestation of harvested or otherwise denuded areas, and setting minimum stocking levels for immature stands and minimum harvest ages for matured stands.

On the economic front, forest use as sinks could be promoted through subsidies. These may be payments, goods or services given to forest owners to promote management for maximal carbon sequestration- for example, rewarding owners for extending rotations or reforesting with species that fix particularly high amounts of carbon. The subsidies could also be in the form of enhanced government acquisition and management of lands for carbon sequestration, or of partial interests in lands. Governments could also spend money on better enforcement of general forest protection laws or on promoting the tending of young stands for better growth and higher stability.

Government could also promote forest carbon sequestration using informal mechanisms. These include informing landowners about management options and advantages through specialized extension services, guiding manufacturers and consumers of forest products on ways to reduce waste, certifying the success of private sequestration efforts, offering help in forest planning to consider GHG impacts and promoting research on forest management for carbon sequestration.

Policies to Mitigate Climate Change Within the Forest Sector

Countries have different types of policy levers available to enhance carbon sequestration in forest biomass. The potential approaches according to Sohngen and Beach (2006) can be categorized into three general types of programs: (1) project-based approaches that consider only individual carbon projects in individual areas, (2) comprehensive approaches that treat all forests as possible emission sources, and (3) indirect approaches aimed at creating systematic change in the forestry and land-using sector. Each is described below.

Project-Based Approaches

This type of approach considers the forest sector as an offset for other sectors that have caps on GHG emissions in place. For instance, energy-producing sectors with emission caps could develop projects (e.g., afforestation, reforestation, improved management) in specific forests to increase the overall quantity of carbon sequestered on those sites. Alternatively, the sectors that have caps can purchase offsets from project developers and credit those against their emissions. Two established carbon markets that allow forestry credits to be used as offsets following the project-based approach are the Australian New South Wales carbon market and the United States Chicago Climate Change carbon market (though purely voluntary).

Comprehensive Approaches

This approach treats the forestry sector like other sectors as a potential emission source. Any increase in the overall carbon stock within the country's boundary from period to period would result in net credits, while any reduction would result in additional emissions that must be counted under the country's overall cap. Within the context of a comprehensive approach, a country can use a range of policies (or a combination of policies) to sequester carbon or reduce emissions, including taxes on emissions from individual forests when they occur, subsidies on sequestration, or caps for individual landowners. The use of these policies would suggest that landowners retain the rights to the carbon embodied on the land. Alternatively, countries may nationalize all of the carbon embodied in forests and design programs to increase carbon in the forests through subsidy payments for related practices, such as reforestation, afforestation, improved forest management, and taxes on specific types of products with a short shelf life.

The general idea of the comprehensive programs is that countries would treat emissions from forestry at the national level no differently than they treat emissions from other sources. As a consequence, they would also treat net national sequestration as an offset for emissions from other sources. The comprehensive approach would require a substantive investment in inventory data collection over a large proportion of the landscape and, thus, has not been widely considered in the policy realm.

Indirect Approaches

The use of project-based approaches designed to generate carbon credits as a GHG mitigation activity does not preclude government provision of carbon sequestration on lands they manage or own or on privately owned land. Many countries have programs aimed at altering specific types of land uses. For instance, the U.S. government pays some farmers to set aside farm land from production to improve habitat or streamside vegetation. These projects may improve carbon on those sites and, therefore, also be marketable as carbon credits. The rules could be written to allow individual landowners to sell the carbon credits on this land.

In addition, the United States and Europe subsidize certain types of agricultural practices or products and potentially increase the area of agricultural land devoted to those practices or products relative to what it would otherwise be. By altering these programs, the United States and Europe could alter the carbon in their land base. For example, traditional agricultural commodity programs could be adjusted to provide additional incentives for crops that are most suitable to conservation tillage. It is important to recognize that governments can, and may, try to influence carbon outcomes through policies that are not even directly related to carbon.

Conclusion

Although tropical Africa's contribution to global carbon emissions is small, its role in a global carbon abatement strategy is important. The world's remaining primary forests, particularly those in the tropics, represent huge banks of sequestered carbon. The protection of these forests that otherwise would be degraded therefore, presents an opportunity to immediately impact carbon flows. The avoidance and mitigation of carbon releases from these banks provides the quickest, forestry-based opportunity to slow the accumulation of carbon dioxide, the most important GHG into the atmosphere. While it is inevitable that energy consumption and carbon emissions will increase as tropical Africa develops, many of the measures discussed in this paper are available to countries in the region at low cost and with external donor support. To exploit these opportunities, the countries of Africa must develop strong regional and national initiatives. Human capacity development in improved forest management such as Reduced Impact Logging (RIL) is important, so also is the need to understand fully greenhouse phenomena and related issues. A regional approach is an important prerequisite for successful mobilization of local capital and technological capabilities.

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