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SUSTAINING CARBON SINK POTENTIALS IN TROPICAL FOREST

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ABSTRACT
Forests are major carbon sinks and providers of environmental services which are currently not paid for. Despite the increasing awareness in recent years of the unique and crucial role that forests play in climate stabilization; with their capacity to protect water, soil, and biodiversity, deforestation continues at an alarming rate. Deforestation is by far the leading contributor to greenhouse gas emissions in developing countries. Reducing carbon emissions from deforestation and degradation in developing countries is of central importance in efforts to combat climate change. In order to solve the climate change problem, there is need to reduce atmospheric concentration of green gases to a safe level. This paper examines the measures of sustaining carbon sink potentials in tropical forest.

Key words: Carbon sequestration, tropical forest, deforestation, conservation

INTRODUCTION

Greenhouse gases play an important role on Earth's climate. When the concentration of greenhouse gasses in the atmosphere increased, temperature at the Earth's surface is expected to rise thereby resulting in global warming. Global climate change is a widespread and growing concern that has led to extensive discussions and negotiations internationally. Intergovernmental Panel on Climate Change (IPCC), (2007) report predicted increase in temperature with more precision at 1.8^{o}C to 4^{o}C at the end of the century. Increase in surface air temperature level was linked to increase in the concentration of Carbon dioxide (CO_2) in the atmosphere. Climate change mitigation strategies have focused on reducing emissions of greenhouse gases (GHGs), especially carbon dioxide (CO2). CO_2 is one of the more abundant greenhouse gases and a primary agent of global warming. Its concentration in the atmosphere is the result of a cycle between different carbon pools of which CO_2 is the product of the oxidation of carbon from these pools.

The amount of carbon dioxide in the atmosphere has increased from 280ppm in the pre-industrial era (1750) to 379ppm in 2005, and is increasing by 1.5ppm per year (IPCC, 2007). Carbon (C) is accumulating in the atmosphere and the largest proportion is resulting from the burning of fossil fuels, deforestation and the conversion of tropical forests to agricultural production. One significant source of CO_2 emissions is deforestation. When forests are cleared or degraded, their stored carbon is released into the atmosphere as carbon dioxide. FAO (2005) stated that in Africa, deforestation accounts for nearly 70% of total emissions. Forests store and release carbon dioxide through natural processes. Forest trees are considered as an important factor in mitigating climate change because of their role in carbon sequestration – the process of removing carbon dioxide (CO2) from the atmosphere and 'storing' it in plants that use sunlight to turn CO_2 into biomass and oxygen (Tagupa *et. al*, 2010).

Forests play a significant role in the global carbon cycle, having absorbed approximately one third of anthropogenic emissions of carbon dioxide (CO_2) from the atmosphere (Percy *et al* 2003). However, our activities in the forest have also been a source of carbon emitted to the atmosphere, with deforestation (primarily in the tropics) contributing about one fifth of the annual anthropogenic emissions. Despite the increasing awareness in recent years of the unique and crucial role that forests play in climate stabilization, not to mention their capacity to protect water, soil, and biodiversity, deforestation continues at an alarming rate. Reducing deforestation to lower CO_2 emissions is seen as one of the least costly methods of mitigating climate change. To help mitigate the worst effects of climate change, nations should reduce net global warming emissions from tropical forests 50 percent by 2020, and bring them to zero by 2030 (Elias and Boucher 2010). However, a rapid reduction in deforestation and forest degradation will not be enough to achieve those goals. These nations must also scale up activities that increase carbon sequestration in tropical forests. This review therefore provides background on how forestry practices can shift the role of tropical forests with respect to climate change from being sources of carbon emissions to sequestering carbon and reducing the impact of climate change, among other benefits.

Forests and climate change

In 2006, the U.N. Food and Agriculture Organization (FAO) reported that forests cover nearly 4 billion hectares (about 30 percent of the world's land area). Forests are important carbon pools which continuously exchange CO_2 with the atmosphere, due to both natural processes and human action. Forests sequester and store more carbon than any other terrestrial ecosystem and are an important natural 'brake' on climate change. It serves as carbon sinks, absorbing carbon from the atmosphere and storing it in the wood, soil, and other organic material. Reducing the world's forested area permanently decreases the Earth's capacity to store future carbon emissions. Understanding forests' participation in the greenhouse effect requires a better understanding of the carbon cycle at the forest level. At the global level, 19 percent of the carbon in the earth's biosphere is stored in plants, and 81 percent in the soil. In all forests, tropical, temperate and boreal together, approximately 31 percent of the carbon is stored in the biomass and 69 percent in the soil. In tropical forests, approximately 50 percent of the carbon is stored in the biomass and 50 percent in the soil (IPCC, 2000). The process of photosynthesis explains why forests function as CO_2 sinks, removing CO_2 from the atmosphere. Atmospheric CO_2 is fixed in the plant's chlorophyll parts and the carbon is integrated to complex organic molecules which are then used by the whole plant.

The carbon cycle (fig 1) in a given forest is influenced by climatic conditions and atmospheric concentrations of CO_2. Changing climatic conditions will inevitably have serious impacts on forests. Forecasting these climatic changes has proven difficult, as they are largely dependent on future emission levels and many underlying uncertainties associated with climate change. Climate models developed in the 90's have shown that global surface air temperature may increase by 1.4^{o}C to 5.8^{o}C at the end of the century (IPCC, 2001; Rahmstorf and Ganopolski, 1999). Research has however showed that mean global temperatures are rising, and will continue to rise under increased emissions levels. Increased intensity of precipitation, primarily in the form of rain (Frumhoff et al. 2007), coupled with decreased frequency of storms will have serious impacts on forests (Hayhoe et al. 2007). White *et al*. (1999) found through modeling that after 2050, the continued increase in temperature and precipitation will reach a threshold where they begin to adversely affect global forests and Net Primary Production (NPP) will decline.

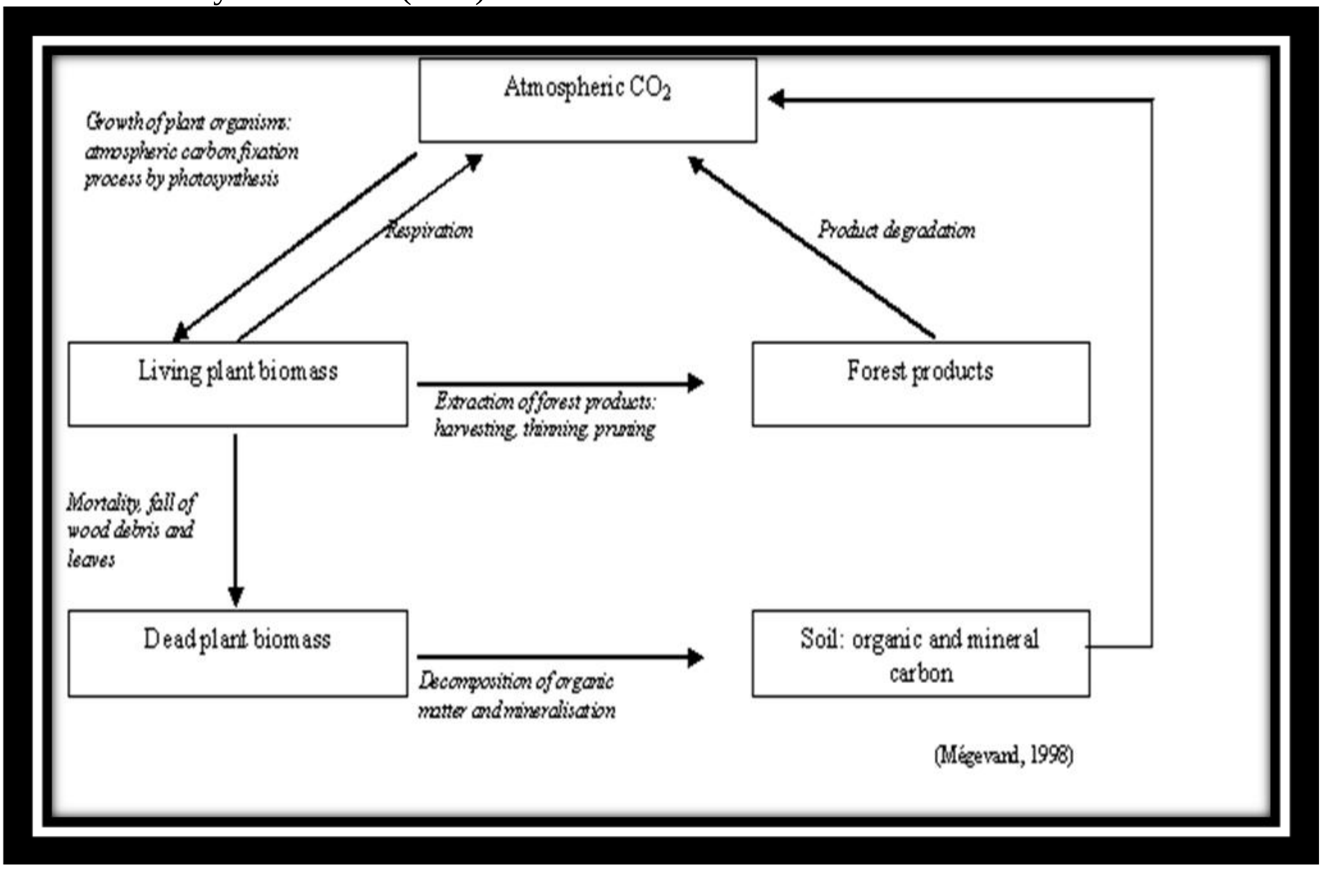

Fig 1: Carbon cycle in the forest
Source: Megevand 1998

Natural disturbances play a critical role in stand development (Franklin *et al.* 2002, Seymour *et al.* 2002, and Keeton *et al.* 2007) and have significant effects on carbon storage (McNulty 2002). Changes in disturbance regimes, caused by global climate change and spread of exotic organisms, will likely impact carbon storage in forest ecosystems. The impact of these changes should be considered when addressing the issue of permanence of carbon stored in forests in relation to carbon offset programs. The long-term future of the biospheric carbon pool is still a big question. Several bio-climatic models indicate that the ecosystems' absorption capacity is approaching its upper limit and should diminish in the future, possibly even reversing direction within 50 to 150 years, with forests becoming a net source of CO_2. Indeed, global warming could cause an increase in heterotrophic respiration and the decomposition of organic matter, and a simultaneous decrease of the sink effectiveness, thereby transforming the forestry ecosystems into a net source of CO_2.

Tropical forest: an option for carbon sinks

Tropical forests are generally defined by their location -between the Tropic of Cancer and the Tropic of Capricorn (23° North and South of the Equator, respectively). Some tropical forests are relatively dry, open woodlands, but many receive heavy rains and are called moist or humid tropical forests; these are the classic rainforests, or "jungles." Tropical forests contain an enormous diversity of "hardwood" tree species. Moist tropical forests are important for carbon sequestration, because they typically have high carbon contents - averaging nearly 110 tons per acre. About half of the carbon in moist tropical forests is contained in the vegetation, a higher percentage and a much higher quantity than in any other biome. Concern about rising atmospheric concentrations of greenhouse gases has prompted the search for methods of sequestering carbon; varieties of strategies are therefore needed to reduce CO_2 emissions and remove carbon from the atmosphere in order to mitigate the potential effects of global warming and climate change (Wigley, 1993). One possible mechanism for mitigating CO_2 emission is therefore its sequestration, or redistribution from the air to soils, terrestrial biomass, geologic formations, and the oceans. The idea of Reducing Emissions from Deforestation known as RED was first introduced by Participants in the United Nation's Framework Convention on Climate Change at the 13th Conference of the Parties in 2007. In 2009 at the fifteenth conference, this idea was expanded to include reducing degradation as well as deforestation of tropical forests, conserving their carbon stocks, managing these forests sustainably, and increasing the rate at which they sequester carbon. The mechanism to pay developing nations to pursue these activities is known as Reducing Emissions from Deforestation and Forest Degradation plus (REED+). The first two of these activities-reducing deforestation and forest degradation-are the fastest and most cost-effective way to reduce carbon dioxide emissions from tropical forests (Angelsen *et al.* 2009, Verchot *et al.* 2010). If acted on quickly, those two activities will also have the biggest impact on climate change of all REDD+ activities (Niles *et al.* 2002). The third activity-conserving carbon stocks is also a critical part of the REDD+ mechanism. However, the fourth and fifth REDD+ activities- managing tropical forests sustainably, and boosting their ability to sequester carbon are key to converting these forests into a net carbon sink. That is because while natural regrowth is creating secondary forests in the tropics (Wright 2010), a REDD+ mechanism could spur developing countries to increase the amount of land devoted to such forests, and to accelerate their growth rates and thus the rates at which they sequester carbon.

Strategies for sustaining carbon sink potential of tropical forest

Most tropical forests are already doomed but present effort can still save the remaining resources for the future. Activities to enhance the rate at which tropical forests sequester carbon are especially important in the many large developing countries. Sequestration of carbon in terrestrial ecosystems is a low-cost option that may be available in the near-term to mitigate increasing atmospheric CO_2 concentrations, while providing additional benefits. Carbon sequestration through forestry is a function of the amount of biomass in a given area. Therefore, any activity or management practice that changes the amount of biomass in an area has an effect on its capacity to store or sequester carbon. Forest management practices can be used to reduce the accumulation of greenhouse gases in the atmosphere through two different approaches. One is by actively increasing the amount or rate of accumulation of carbon in the area. The second is by preventing or reducing the rate of release of carbon already fixed.

Creating carbon sinks

The most obvious approach to achieve the fixation of carbon is to plant trees. However, the effectiveness and feasibility of carbon sequestration through forestry varies widely and depend on factors such as site, species and management practices. Afforestation and reforestation projects replace non-forest land with new forest cover. Afforestation differs slightly from reforestation in that it uses land that was not formerly forestland. Both projects are effective ways to increase carbon absorption and reverse desertification, which is often caused by deforestation and poor agricultural practices. Planting new forests, rehabilitating degraded forests and enriching existing forests contribute to mitigating climate change as these actions increase the rate and quantity of carbon sequestration in biomass. Winjum, *et al.,*(1992) stated that reforestation could store about 1.3 metric tons of carbon per hectare per year. This potential has certain physical limitations such as plant growth and available area. The combination of climatic conditions favourable for tree growth, land availability and abundance of labour force favour the development of forestry schemes in tropical countries as opposed to temperate countries. Perez-Garcia *et al.,* (1997) have suggested that the additional carbon sequestration from afforestation and reforestation could offset the carbon release from deforestation. They asserted that harvesting “over-mature” forests sequesters additional carbon, because:

- Very old forests sequester little additional carbon (the amount stored is large, but the annual addition is small or even negative)
- Wood products made from the timber continue to store carbon for decades
- Newly established stands grow vigorously, sequestering large amounts of carbon.

Vitousek, (1991) disputed these claims, and emphasised that harvesting old-growth forests results in a net release of carbon. Luyssaert *et al*., (2008) stated that carbon continues to accumulate in old-growth forests for centuries, long after the traditional definition of over-mature. According to Mackey *et al*., (2008), *intact* (uncut) natural forests store much greater volumes of carbon than do mature plantations as much as three times as much carbon.

Agro-forestry and the planting of multiple- use trees (fruit trees, rubber wood, etc.) also contribute to this objective. Agro-forestry practice extend the period of agricultural production on the land, therefore reducing the need to clear additional forestland. For this reason, it is considered a practice that can help slow tropical deforestation. Agroforestry has a greater potential to sequester and store carbon than most land-use changes. Dixon *et al.* (1993) stated that in areas where land use is primarily allocated to agriculture or grazing, the introduction of agroforestry practices could be a good way to promote carbon sequestration. The use of agroforestry practices across the humid tropics could sequester 1.5 to 3.5 metric tons of carbon per hectare each year (Montagnini and Nair 2004; Schroeder 1993). Monocultures are a very efficient way of promoting biomass and carbon accumulation, and tend to be easier to manage than multi-species stands or natural forests (Evans 1992).

Protect existing forests to reduce emissions from deforestation

Deforestation leads to increased levels of carbon emissions and continued loss of biodiversity. The most obvious option for preventing the release of carbon fixed in vegetation is direct conservation of forests. A large proportion of land under forest cover is threatened with conversion into other forms of land use which have lower value as carbon sinks (Dixon *et al.* 1994). Some of the main pressures are conversion to agriculture and pasture, logging operations, and urbanization (World Resources Institute 1990). Avoiding deforestation remains by and large the biggest challenge in the forestry sector. The carbon reservoir in the forest biomass and soils is very large, highlighting the importance of conserving natural forest, and eliminating agricultural practices which contribute to the deterioration of these reservoirs. But the key underlying force behind deforestation is poverty and lack of economic alternatives. Low wages, unemployment, and lack of income for farmers and landless people force people to convert forestland for basic income and subsistence needs. There is a direct link between poverty and deforestation. In order to protect existing forests to reduce emissions from deforestation, there should be creation of economic incentives or compensation for conservation.

Conservation activities aim to protect a forest area threatened by human-induced deforestation, particularly from farming. Climate specialists consider this conservation option to be the "best strategy for sink maintenance" to the extent that it contributes more effectively to carbon storage and preserves the biodiversity associated with old-growth forests. Conservation of forests play a double role in relation to carbon sinks. Firstly, it prevents the emission of carbon which would be caused by decomposition of the forest biomass. It has been estimated that deforestation contributes to 30% of the current global CO_2 emissions (Houghton *et al.* 1992). Secondly, conservation prevents the reduction in areas with potential for active carbon sequestration. However, the carbon benefits of conserving tropical forests and enhancing their ability to sequester carbon will vary across regions with different land-use histories.

Improve forestry techniques to reduce emissions

Activities that reduce the rates of carbon emissions are also of great importance. These include reduction in rates of deforestation, introduction of techniques for controlled logging, and fire prevention. Numerous forestry activities emit greenhouse gases; these emissions can be curtailed by applying appropriate techniques. It is estimated that 15 million hectares of tropical forests are logged yearly throughout the world (Singh 1993). Forest harvesting can cause serious damage to the soil and the forest stand when carried out inappropriately. Poore (1989) stated that the majority of logging operations in tropical countries are considered unsustainable and damaging. The implementation of techniques for reducing the impact of logging, thus avoiding unnecessary destruction of biomass and release of carbon, has great potential.

Timber processing also generates a considerable quantity of waste wood, which could either be reduced, or used as a raw material for production or as fuel. Improving the forest industry's efficiency helps limiting the amount of wood waste created by the production process. Using wood wastes in combined heat and power generation, thereby simultaneously generating heat for kiln-drying of wood, energy for running the machines, and electric power for the outside would reduce emissions and valorize these residues, which can substitute for fossil fuels[3]. Moreover, charcoal production also is a process of widely varying efficiency, depending on the method and techniques used, which could be improved.

Substitution of fossil fuel

Producing wood for energy purposes mitigates climate change by combining sink action with emissions reduction. Substituting fossil fuels, such as coal, natural gas, or oil by fuel wood for domestic use, electricity production, or industrial use, e.g. in iron smelters, reduces CO_2 emissions because wood is renewable. The expected sequestration of carbon through the growth of trees after sustainable harvest compensates for the CO_2 emitted by combustion. However, this assumes that fuel wood production does not cause irreversible deforestation, i.e. that wood stocks are managed in a sustainable manner. Good management may even increase the productivity of forests and hence their sequestration capacity both in above-ground and below-ground biomass. Different actions related to fuel wood can be taken: Increasing fuel wood supply by creating new plantations or enhancing productivity of existing forests through forest management. The contribution to climate change mitigation depends on the size and permanence of the carbon pool, and on the fuel wood increment. Increasing the energy efficiency of fuel wood use and derived products. Charcoal will often replace fuel wood in households. Improving and adapting stoves is necessary in order to raise energy efficiency and avoid the over-exploitation of certain species which have low wood density and burn rapidly. Charcoal contains two to five times more energy than wood by weight. Its use may also improve the distribution of fuel wood resources by reducing transportation costs from distant forest areas increasing the efficiency of charcoal production.

CONCLUSION

The world has come to recognize the realities of excess CO_2 emissions and their effects on global warming. Despite significant contributions of Tropical forests ecosystem to the well-being of the world in terms of the economy and the environment, it is sad to note that our forests are rapidly "dying" without any visible remedial actions being taken. The forestry sector is also a major contributor to both greenhouse gas emissions and carbon sequestration. The consequence of inadequate management of tropical forests dual role is partly felt by the level of associated environmental problems particularly deforestation. Therefore sustaining the ability of our tropical forest to sequester carbon should be our priority against all odds.

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