

Forestry-Based Global Warming Mitigation¹

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Global Warming

Scientific community is almost confirm that the global climate system is facing a non-cyclic rise in air temperature due to the accumulation of atmospheric greenhouse gases (GHGs) released by human activities. The increasing atmospheric GHG concentration is altering the balance between energy received from the sun to the Earth and outgoing energy. Solar energy arrives in the form of short-wave radiation, and the proportion of it penetrating through the atmosphere warms the Earth's surface. The Earth's surface releases the absorbed energy back into the space in the form of long-wave radiation. GHGs absorb this radiation more efficiently than other gases in the air. The absorbed energy ultimately heats the atmosphere, which is termed as global warming.

According to the Intergovernmental Panel on Climate Change (IPCC), there has been an unprecedented warming trend during the 20th century. The current average global surface temperature of 15°C is nearly 0.6°C higher than it was a 100 years ago. Scientists now estimate that the average global surface temperature will rise another 1.4°C to 5.8°C by the end of the 21st century. Precipitation is also on the rise. In the northern hemisphere, precipitation has increased by 0.5% to 1.0% per decade whereas the increase in tropical countries has been 0.2% to 0.3% per decade (CIDA 2001).

Factors Causing Global Warming

The whole processes that control the climatic system may be divided into internal and external types. The climatic system is expected to vary within itself even in the absence of external variability. In addition to internal variability, many external factors could change the climate, including both natural processes such as volcanic eruptions and changes in solar output and man-made processes such as increasing concentration of GHG.

Table 1: Principal Greenhouse Gases

Greenhouse Gases	Importance to Climate change	Trend in the Atmosphere	Land Use Related sources of Greenhouse Gases
Carbon dioxide	Very high	Increasing; +30% in the last 250 years	Mostly produced by deforestation and forest fires
Methane	Moderate	Increasing; +145% in the last 250 years	Generated by livestock waste, the decomposition of wetlands, and burning of biomass
Nitrous oxide (N ₂ O)	Moderate	Increasing; +15% in last 250 years	Caused by deforestation, burning of other biomass, and application of nitrogen fertilizer
Carbon monoxide	Moderate	Increasing	Comes from the incomplete burning of pasture and grasslands

Source: modified from Ciesla, 1995 in CIDA 2001

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Table 1. illustrates the main greenhouse gases that are related to land use. In addition to those mentioned in the table; water vapour and industrial emissions (in particular, nitrogen oxides (NO_x), ozone, sulphur dioxide, CFCs, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluorides) are generally very important as greenhouse gases, although they are not significant in terms of their impact on forests or forests' ability to mitigate climate change.

According to Andrasko (1990), major human-made sources include the burning of fossil fuels, deforestation and the burning of wood and charcoal. Scientists have suggested for more than 100 years, and increasingly during the past decade, that these increasing emissions may affect the atmosphere's radiative balance leading to a significant and long-term increase in the earth's average temperature.

In addition to anthropogenic-induced climate change, there are short-term variations in global temperatures that are associated with atmospheric disturbances resulting from solar activity, geological events like volcanic eruptions, or temporary shifts in ocean currents like the influences of El Niño and La Niña in the Pacific Ocean. The Earth's climate has a history of cycles of warmer periods followed by cooler ones. However, the principal concern today is that the present trend is not cyclical in nature; rather it is a long-term warming of the global climate. Since the early 1900s, a definite warming trend has been detected which is considered by scientists to be distinct from the cyclical variations that the Earth has experienced for millennia (CIDA 2001).

Forest Management for the Mitigation

At the global scale, the link between forests and global warming is through the carbon cycle. Forest is capable of sequestering large amount of carbon, which is one of the major constituents of GHGs. The notion of compensating for rising atmospheric CO₂ concentration through global scale afforestation was first put forward in the late 1970s (Dyson 1977 in Moura-Costa et. al., 1998). From then till date, forestry based carbon offsets have evolved from a theoretical idea towards being a market-based instrument. Green plants remove carbon dioxide from the atmosphere in the process of photosynthesis, using it to make sugars and other organic compounds used for growth and metabolism. Long-lived woody plants store carbon in wood and other tissues until they die and decompose from which the carbon in their wood may be released to the atmosphere as CO₂, CO or methane, or it may be incorporated into the soil as organic matter.

Forests with net growth are capable of net absorption of CO₂, whereas mature forests with little growth hold carbon stocks but are unable to absorb additional CO₂. Since rate of CO₂ absorption is directly proportional to the rate of growth, it stands to reason that 'preservation' of natural forests is a relatively inefficient means of sequestering CO₂. On the other hand, forest management based on harvesting at the optimal rotation, efficient conversion of the wood into durable products and appropriate regeneration would maximize the sequestering of CO₂. Hence, increasing the production of industrial wood products produced from wood

obtained on a sustainable basis from managed natural forest, and especially from plantations, would be the most efficient means of using forests to sequester CO₂ (Kyrklund 1990).

According to Brown et. al., (1996), forests can be managed in three different ways so as to help in carbon offset objective. The management options are;

- i. management for carbon conservation
- ii. management for carbon storage, and
- iii. management for carbon substitution

Conservation management's goal is maintaining to present C emissions by conserving existing C pools in forest vegetation and soil as much as possible through options such as controlling deforestation, protection forest in reserves, changing harvesting regimes and controlling other anthropogenic disturbances such as fire, and pest outbreaks. The goal of storage management is to expand the storage of C in the forest ecosystems by increasing the area and/or biomass and soil C density of natural and plantation forests and to increase storage in durable wood products. Substitution management aims at increasing the transfer of forest biomass C into products (eg. Construction materials and bio fuels) rather than using fossil-fuels based energy and products, cement based products and other building materials.

The Kyoto Protocol

The most important aspect of the Kyoto Protocol is the binding commitment by 39 developed countries and countries with economics in transition to reduce their GHG emissions by an average of 5.2 percent of 1990 levels by the commitment period 2008 to 2012. Another important output of the agreement was the recognition of forestry activities or 'sinks' as valid option for reducing the net concentration atmosphere Greenhouse Gases (Moura-Costa 2001). Kyoto Protocol proposes three instruments to reduce emissions: joint implementation, emission trading, and the Clean Development Mechanism. What is significant in the Kyoto Protocol is that terrestrial carbon sources and sinks were included in the emission reduction framework, in addition to the reductions in fossil fuel consumption. This emphasizes the role of forests as carbon sinks in both developed and developing countries, and as carbon sources, especially in developing countries.

The protocol includes forestry, but the inclusion is burdened with several weak points as summarized by Solberg (1998) as below;

- Only planting (after 1990) is given credit. No provision is made for natural regeneration, adjustment of thinning and felling regimes and other types of silvicultural system.
- Deforestation (after 1990) is included as a source of CO₂, but it remains unclear whether stopping deforestation, or rehabilitation of degraded land as a net sink is included.
- The end use of the timber felled is not considered which could easily give a wrong signal.

Economics of Forestry Measures

Economic analysis of any forestry project to mitigate C emission is essential prior to its initiation so as to provide all the details required in choosing the best management option. Although there are many literatures on the forestry projects that refer with the cost and

benefit analysis of such projects, the actual task is lacking. The carbon offset benefit and other benefits due to the management should be compared with the costs involved. A necessary condition of implementing forestry measures in C mitigation is that they are no more costly than the least efficient measures for this purpose implemented in other sectors. However, there are two vital questions; the efficiency of these measures relative to possible activities in other sectors and the implementation of these measures.

According to Solberg (1998), the first cost efficiency studies included in the costs only expenditures on the plantation. The first economic model to incorporate carbon sequestration in a dynamic optimisation setting for a forest consisting of several stands with different species, site classes, ages, densities, etc. and optimising the forest management regime with various constraints on carbon sequestration or harvest level is documented in Hoen and Solberg (1994). Few economic analyses of the different possible forms of substitution exist, but nearly all are partial analyses which do not consider the overall demand/supply impacts.

Conclusion

Human activities is a major factor for global warming, directly through the emission of GHGs from the industrial sector or indirectly through the destruction of natural vegetation of the Earth. Forests do have a compensating effect on the rising atmospheric carbon dioxide concentration wherein the long-lived woody vegetation are capable of storing carbon in the wood and other tissues. Slowing deforestation rates, expanding the size of existing forests and substituting some proportion of fossil fuels in energy production with forest based fuels can contribute to the mitigation of global warming (Brown et al. 1993 in Koskela et al., 2000). The Kyoto Protocol has identified forests sector as a "sink" of carbon as a result of which there is a potential of market for carbon sequestration in the forestry sector. Finally, it is essential to find out the efficiency of any forestry measures and needs to be compared with that of other sectors, when they are actually being implemented in the real world.

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