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Carbon Dynamics of Forests as a Proactive Tool in the Hands of Developed Nations and World Conclaves

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Abstract: ***The forests contain all the resources for existence of life on Earth like food, water, materials for shelter, clothing, etc. We need forests for survival and we are destroying them. Forest cover is defined as an area of more than 1 ha with a density of 10 percent and above. A forest is a carbon sink because it absorbs more carbon than it releases and stores it for an indefinite period. Photosynthesis is sequestration of atmospheric carbon dioxide and an effective strategy for reducing global warming .Tropical rainforests play a vital role in regulating weather through rainfall. Since a forest can intercept rainfall, it will prevent soil loss. Flora and fauna form a major part of forest biodiversity and conservation of forests leads to preservation of the forest ecosystem. If the forests are disturbed, the sequestered carbon will move back to the atmosphere causing climate change. The Kyoto Protocol suggests that agroforestry is a means to achieve emission reduction but FERN strongly disagrees with this assumption. Protection of primary forest should be top priority to reduce carbon emission. Agroforestry and plantations can help provide the necessary wood products from forest land that has already been cleared.***

Keywords: Forest cover, carbon sink, sequestration, Kyoto protocol, FERN

1. Introduction

"*It is imperative to maintain portions of the wilderness untouched so that a tree will rot where it falls, a waterfall will pour its curve without generating electricity, a trumpeter swan may float on uncontaminated water and moderns may at least see what their ancestors knew in their nerves and blood*". - Bernard DeVoto (1)

The forests contain all the resources necessary, for existence of life on Earth. These include food, water, materials for shelter, clothing, etc. Each and every need of human beings, related to survival, can be provided for by the ecosystems of forests. Secondly, the forests sustain the biological diversity necessary to maintain the various food chains that are the very foundation of our nourishment. As we progressively destroy the forests, we break down those food chain ecosystems and as a consequence we generate famines and droughts for ourselves. (2) Thirdly, it is believed by scientists that mankind evolved from hominids that originally lived in forests, thus the forests are genetically involved in our life patterns. The forests would naturally have been the source of all sustenance for our ancestors, and therefore we might have inherited a psychological need for their presence, even if today we are ready to comprise for their physical existence. (3)

2. Forest and Forest-Covers

A forest is best defined as an ecosystem or assemblage of ecosystems dominated by trees and other woody vegetation. The living parts of a forest include trees, shrubs, vines, grasses and other herbaceous (non-woody) plants, mosses, algae, fungi, insects, mammals, birds, reptiles, amphibians, and microorganisms living on the plants and animals and those present in the soil.

Picture 1(from Google)

These interact with one another and with the non-living part of the environment which includes the soil, water and minerals, to make up what we call a forest. (4)

Definition of forests, as adopted by the United Nations Framework Convention on Climate Change (UNFCCC) in 2002, which was later extended to land-use change and forestry activities carried out under the Clean Development Mechanism (CDM) of the Kyoto Protocol, is a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees with the potential to reach a minimum height of 2-5 meters at maturity *in situ*. A forest may consist either of closed forest formations or open forests, where trees of various heights and heavy undergrowth, cover a high proportion of the ground. All plantations which can reach a crown density of 10-30 per cent or tree height of 2-5 meters are included under forest.

Forest cover is defined as an area of more than 1 ha in extent with a tree canopy density of 10 percent and above. The minimum area of 1 ha for forest cover has been kept because this is the smallest area that can be delineated on a map at 1:50,000 scale. All types of trees (bamboos, fruits or palms,

etc.) on all types of land (forest, private, community or institutional) satisfying the basic criteria of canopy density, more than 10 percent have been delineated as forest cover. (5)

India has asked the Clean Development Mechanism (CDM) Executive Board, set up under the Kyoto Protocol, to change the definition of ”forest" for India in an attempt to encourage small farmers to take up the projects in the forestry sector. As per the current definition of a "forest", only that project can qualify for the CDM provided it is grown within 30 per cent crown density in an area of 0.05 hectares with tree height of five meters. R K Sethi, Chairman, CDM Executive Board, has requested the CDM to relax the definition for forests, making it 15 per cent crown density with two meters height for trees, with the land area remaining at 0.05 hectares. The change in definition is being sought given that small communities and farmers are not able to take up afforestation and take the benefits of the growing carbon credits market. The new norms would help the local farmers to grow dwarf varieties of tree alongside the seasonal-crops ensuring that they do not have to give away their agricultural income. The small varieties of trees would take less time to grow and help earn carbon credits fast. (6)

3. Forests as Carbon Sinks

Carbon dioxide makes up just 0.035 percent of the atmosphere, but is the most abundant of the greenhouse gases which include methane, nitrous oxide, ozone, and CFCs. Since the Industrial Age, the concentration of carbon dioxide in the atmosphere has risen from about 280 ppm (parts per million) to 377 ppm, a 35 percent increase in the atmosphere. It is estimated that without the removal of CO_2 from the atmosphere via carbon sinks, the present concentration of CO_2 (377 ppm) would be nearly 450 ppm (Gillon, 2001). All greenhouse gases play a role in protecting the earth but abnormally high concentrations of these gases cause overall warming of the global climate.(7)

A vital role of forests is recycling of air in the lower atmosphere by storing and releasing carbon dioxide through natural processes. A tree takes in CO_2 from the atmosphere and releases oxygen in the process of photosynthesis. The carbon that is taken from the air is incorporated into sugars (such as glucose), which are the building blocks for production of wood.

A carbon sink is anything that absorbs more carbon than it releases. Forests, soils, oceans and the atmosphere all store carbon and this carbon moves between them in a continuous cycle. A carbon sink is a natural or artificial reservoir that accumulates and stores carbon compounds for an indefinite period. In the case of a growing forest, carbon storage is in the form of wood, vegetation or soil. Young fast-growing forests absorb carbon dioxide more rapidly than older forests. An old forest is characterized by slow-growing trees and carbon losses due to death and decay that may translate to a net loss of carbon over time. But as explained by Sedjo (2001) a carbon sink such as an old forest “may not be capturing any new carbon but can continue to hold large volumes of carbon as biomass over long periods of time”. Trees and woods are carbon sinks, accumulating carbon as they grow and acting as stable carbon stores upon maturity. This carbon storage applies even when trees are converted to lumber. When trees die or succumb to fire, their stored carbon is released back into the cycle through decay and combustion. Carbon sinks can help offset environmental damage of energy intensive activities and the Kyoto Protocol recognizes carbon sinks as a form of a carbon offset.

4. Forests as Carbon Sequestrates

Carbon sequestration can be explained in a number of ways. Carbon sequestration is the process of removing carbon from the atmosphere and depositing it in a reservoir. When carried out deliberately, it may be referred to as carbon dioxide removal, a form of geo engineering. Carbon sequestration describes long-term storage of carbon dioxide or other forms of carbon to either mitigate or defer global warming. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels.

Carbon dioxide is naturally captured from the atmosphere through biological, chemical or physical processes. Some anthropogenic sequestration techniques exploit these natural processes while some use entirely artificial processes. Carbon dioxide sequestration includes the storage part of carbon capture and storage. This includes large-scale, permanent, artificial capture and sequestration of industrial CO_2 using subsurface saline aquifers, reservoirs, ocean water, aging oil fields, or other carbon sinks.

As a result of photosynthesis carbon dioxide is removed from the atmosphere and stored in biomass. This is a part of the carbon cycle known as carbon sequestration. Simply put, the process by which carbon sinks remove carbon dioxide (CO_2) from the atmosphere is known as carbon sequestration. About half the weight of dry wood is carbon and this carbon is stored or sequestered as long as the wood is in existence. When trees die, decay or burn they release carbon stored in the soils and biomass (organic matter such as stems, stumps and slash) as CO_2 into the atmosphere. Forests contain nearly 75 percent of the earth’s biomass (Cloughesy, 2006), so it is crucial to understand the role forests have with carbon and climate change. (8)

Old-growth forests remove carbon dioxide from the atmosphere at rates that vary with climate and nitrogen deposition. The sequestered carbon dioxide is stored in live woody tissues and slowly decomposing organic matter in litter and soil. Old-growth forests serve as a global carbon dioxide sink, but they are not protected by international treaties, because it is assumed that ageing forests cease to accumulate carbon. In forests between 15 and 800 years of age, net ecosystem productivity (the net carbon balance of the forest including soils) is usually positive. Old-growth forests can accumulate carbon and contain large quantities of it, contrary to the view that they are carbon neutral. Over 30 per cent of the global forest area is unmanaged primary forest, and half of the primary forests (6×10^8 hectares) are located in the boreal and temperate regions of the Northern Hemisphere. These forests alone sequester about 1.3 ± 0.5 gigatonnes of carbon per year. Thus, 15 per cent of the global forest area, which is currently not considered when

offsetting increasing atmospheric carbon dioxide concentrations, provides at least 10 per cent of the global net ecosystem productivity. (9)

5. Forests and the changing hydrological cycle

Humans now use more than 50% of the available fresh water of the earth, and this proportion is to increase to 70% in the next 50 years. Therefore, it is important to attend to each factor that affects the water cycle. The role of rainforests in the global water cycle is small as compared to that of the oceans, it is nevertheless extremely important.

Picture 2 (from Google)

Tropical rainforests play a vital role in the functioning of the earth's natural systems. The forests regulate local and global weather through absorption and creation of rainfall and through exchange of atmospheric gases. For example, the Amazon alone creates 50-80 percent of its own rainfall through transpiration.

Rainforests influence the hydrologic cycle in the following ways:

1) Precipitation

Rainforests release water vapor through leaves by transpiration and evaporation (evapotranspiration, or water lost by transpiration through the stomata in leaves and evaporated by heat). The loss of water to the air by leaves is a critical part of the water cycle of the earth because the water vapor content of the air is continually replenished. More than 50% (even as much as 75% in dense rainforest) of the precipitation striking a rainforest is returned to the atmosphere by evapotranspiration and most of the water released by evapo transpiration, to the atmosphere as water vapor, will be returned to the forest as rain. So rainforests provide their own rainfall and consequently little water will end up in rivers. Evapotranspiration also has a cooling effect, as it takes energy to vaporize water from leaves, and keeps the temperature in the forest relatively constant. Lowered levels of atmospheric water vapor reduce cloud cover and rainfall, so if forest is removed, rainfall in that region will be substantially reduced. This will have grave consequences for even large rainforest reserves. If they are surrounded by deforested land, they will not be able to generate sufficient rain to support them, and they would perish. Cutting the rainforests changes the reflectivity of the earth's surface, which affects global weather by altering wind and ocean current patterns, and changes rainfall distribution. If the forests continue to be destroyed, global weather patterns may become more unstable and extreme.

2) Water regulation and prevention of soil erosion

The movement of water into rivers and other waterways is modulated by forest vegetation. Vegetation increases the ability of soils to retain water, preventing floods and erosion. Since a forest can intercept as much as 50% of the rainfall, it will prevent much soil loss which might otherwise occur from the impact of rain on the land surface. Water passes from rainforests into rivers and streams with much less force, reducing erosion and the threat of floods. Soil erosion is a natural process, and, in fact, healthy for the ecosystem but it has increased due to land use. Land that is used for industrial agriculture generally experiences a greater rate of erosion than that of land under natural vegetation. In an undisturbed forest, the mineral soil is protected by a litter layer and an organic layer. These two layers protect the soil by absorbing the impact of rain drops. These layers and the underlying soil in a forest are porous and highly permeable to rainfall. Typically, only the most severe rainfall and large hailstorm events will lead to overland flow in a forest. Severe fires can lead to significantly increased erosion if followed by heavy rainfall. In the case of construction or road building, when the litter layer is removed or compacted, the susceptibility of the soil to erosion is greatly increased.

One of the main causes of erosive soil loss is the result of slash and burn treatment of tropical forest. When the total ground surface is stripped of vegetation and then seared of all living organisms, the upper soils are vulnerable to both wind and water erosion. In a number of regions of the earth, entire sectors of a country have been rendered unproductive. For example, on the Madagascar high central plateau, comprising approximately ten percent of that country's land area, virtually the entire landscape is sterile of vegetation, with gully erosive furrows typically in excess of 50 meters deep and one kilometer wide. This degrades the soil and causes the soil to become less and less fertile (10).

6. Forests and threatened biodiversity

Flora is the plant life and fauna is the animal life that is present in a particular region or habitat at a particular time. Biodiversity means the diversity of life on our planet, which may be genetic diversity, species diversity, and habitat diversity. Biological diversity is the variety and variability among living organisms and the ecological complexes in which they occur. Thus, the term encompasses different ecosystems, species, genes, and their relative abundance. Flora and fauna form a major part of forest biodiversity. Conservation of biological diversity in forests leads to conservation of essential ecological diversity to preserve the continuity of various food chains operating in the forest ecosystem. The genetic diversity of plants and animals is then preserved. A reservoir of wild animals and plants is preserved, thus enabling them to be introduced, if need be, in the surrounding areas. Biological diversity provides immediate benefits to the society such as recreation and tourism. Biodiversity conservation serves as an insurance policy for the future.

India has a rich and varied assemblage of living organisms. Two of India's greatest mountain ranges, the Eastern Himalayas and the Western Ghats have been designated among the world's eighteen 'hotspots' of biodiversity. There

are over 40,000 plant species in India of which nearly 2,500 are trees (Negi 1994). This accounts for about 12% of the global plant wealth. Amongst the 21,000 species of flowering plants found in India, 5,000 are woody plants. Almost a third of plant species of India are endemic and not found anywhere else in the world (Tewari 1992). The faunal wealth of India is also equally rich. There are over 75,000 species of animals of which about 60,000 are insects, 1,693 fishes, 3,000 birds and 372 mammals.

But In the last few decades we have seen a steady increase in the extinction rate of flora, fauna etc. all over world including India. The report, compiled by the World Conservation Monitoring Centre (WCMC) and the World Conservation Union (IUCN), shows that well over half the threats to tree species arise from loss of habitat, due to agriculture or human settlement. Logging, poor forest management and alien plants that alter native vegetation are also factors.

1) Bhojpatra or Himalayan Birch, a unique tree having tremendous medicinal qualities, is on the verge of extinction at Gangotri forests in Uttarakhand due to its massive uprooting. Environmentalists are now calling for a complete ban on the collection of Bhojpatra from Gangotri. Ayurveda uses Birch in many formulations for obesity, asthma, hysteria, astringent, antiseptic and disorders of lipid metabolism. (11)

2) The top-dying disease of Sundari trees alarmingly increased due to lack of required sweet water flow with nutrients from the river Ganges in the Sundarbans. The disease attacked about 45.2 million trees worth rupees two crore in15 square kilometers of the largest mangrove forest in the world. The top-dying disease increased due to fungus. Increase in salinity in the rivers of the Sundarbans and chemical wastes from the sea caused the disease. (12)

3) The Pai or riverine forest in the Nawabshah district, Sindh, Lahore, is facing serious threat of extinction due to continuous intrusion of land grabbers and water scarcity. The forest which is spread over 1,933 hectares is rich in flora and fauna, has been identified as one of 40 biologically richest eco-regions in the world. The agony of water-starved forest is exacerbated by plantation of eucalyptus trees, a water-consuming species. (13)

4) Ten percent of the world's species of plants and animals live in Brazil, and thousands of those species are at risk of extinction. In order to preserve the habitats of endangered plants and animals, the Amazonians founded the Xixuaú-Xipariná Ecological Reserve, situated on the right hand bank of the Jauaperí River. The Reserve measures 1,72,000 hectares and is the only private nature reserve of this type in the Brazilian Amazon.

Xixuaú-Xipariná Reserve is located deep in the Amazon jungle; it is extremely isolated, accessible only by a 30-40 hour boat trip from the city of Manaus. This isolation has helped preserve hundreds of species that are in danger of extinction elsewhere in the Amazon. (14)

7. Concept of Carbon stores: differently interpreted by FERN and Kyoto Protocol

In the context of climate change, the most important carbon stores are fossil fuel deposits as they have the unique benefit of being buried deep inside the earth and being naturally separated from the carbon cycling in the atmosphere. This separation ends when humans burn coal, oil and natural gas, turning fossil carbon stores into atmospheric carbon. This release of carbon from fossil fuel has caused greenhouse gas (GHG) concentrations in the atmosphere to soar to levels more than 35 per cent higher than that found at the beginning of the industrial revolution.

We are still adding roughly 6 billion tonnes of carbon per year to the atmospheric carbon cycle, significantly altering the global climate thereby (15). If the forests are disturbed, much of the sequestered carbon and even soil carbon will move back to the atmosphere. The Kyoto Protocol suggests that the absorption of carbon dioxide by trees and the soil is a valid means to achieve emission reduction commitments and analogous to cutting carbon dioxide emissions from fossil fuels . However, Forest Ecosystem Research Network (FERN) strongly disagrees with this assumption that planting trees or reducing deforestation is just as good as reducing emissions from burning fossil fuel or reducing warming of earth's surface (16).
Some important facts are:

1) There is general consensus about the need to halt fossil fuel emissions, particularly in the developed and industrialized countries. The majority of the primary forests are in Northern Hemisphere. These countries are not reducing fossil fuel exploitation or incorporating low-carbon economies .They stress upon the forests' ability to sink or store carbon and justify their continued wood or fossil fuel use. Companies who have had their emissions capped are going beyond that cap by similar justification and the result is further rise in global greenhouse gas concentrations.
2) All carbon available in the universe is not the same. Fossil carbon is static, whereas that which is in the atmosphere and the biosphere is mobile and can be converted from one form to another through activities through natural disasters or activities such as forest fires, decay, logging, insect outbreaks, land use changes or decline of forest ecosystems as a result of climate change. Carbon stored in a tree is different from carbon stored in a fossil fuel deposit.
3) Afforestation, especially in northern Tundra region in Canada's Boreal forest may accelerate global warming. Even though carbon is removed from the atmosphere as trees grow, it may not actually benefit the climate. The 'Albedo Effect', is a process which determines how much sunlight is reflected back into space and how much of it warms the Earth's surface. Dark green forests absorb more sunlight than snow covered Tundra. This would add to a warming trend in the climate if large areas that are now covered in highly reflective snow were planted with trees.
4) It is not possible to accurately measure the "sink" effect of a forest, that is, the capacity of a particular forest to store carbon. Trees take in different amounts of carbon

depending upon the weather conditions, the plant species etc. and as yet very little is known about the movement of carbon in forest soils (17).

FERN's analysis has also shown that many tree planting offset projects by the CDM have had, and continue to have, severe impacts on forests and forest dependent communities.

The Kyoto Protocol does not differentiate between forests and plantations, meaning that a substantial percentage of afforestation /reforestation offset projects will result in large-scale tree plantations. The first carbon sink project seeking registration with the Kyoto Protocol's Clean Development Mechanism (CDM) was a eucalyptus plantation in Brazil named "Forests in exhaustion" which are industrial tree plantations of eucalyptus. It is actually a subsidy for industrial tree plantations. These plantations have been intrusive because they have encroached on lands previously occupied by peasants and are now undermining the struggles of the local people who want to recover their lands. The eucalyptus tree plantations have dehydrated the soils because of their capacity to absorb large quantities of soil water (18).

Lands dedicated to carbon sink projects require contractual agreements that lock the land up for years or decades. This seriously means that the carbon sink offsets are effectively grabbing the best land to generate emission rights that allow the most polluting countries and industries to continue polluting while the needs of forest dependent communities in the Global South are unheard of as well as curtailed (17)

8. Conclusion

The size of the global forest carbon stock appears to be declining, thereby contributing to the build-up in atmospheric carbon. Analysts widely agree that the primary cause of the build-up in atmospheric carbon is largely due to fossil fuel burning and its associated emissions. Forestry can play a major role towards increasing the global carbon sequestration. Carbon dioxide is one of the major greenhouse gases contributing to global warming and subject to the Kyoto Protocol. Carbon emissions from deforestation, the burning of fossil fuels, changes in land use, and other human activities are increasing, while the earth's ability to soak up, or "fix" the carbon, is decreasing. Reforestation is one of the long term ways to help restore the environmental balance. The value of forests in sequestering carbon as well as the need of reduction of carbon dioxide emission in the atmosphere is being recognized urgently worldwide. Neither regrowth nor plantations can come close to replacing the full amount of carbon that was present in the primary forest. Sequestration of atmospheric carbon dioxide is an effective strategy for mitigating and reducing global warming and soil is considered to be a major pool of carbon in the biosphere. Therefore, protection of primary forest should be top priority when looking at ways to reduce carbon emission. Since fossil fuels emit large amounts of carbon dioxide we need to develop alternative energy sources and increase energy efficiency.

The most important role that agroforestry and plantations may play is to offset destruction of primary forest by providing the necessary wood products from land that has already been cleared. These plantations should provide competitive biomass accumulation rates comparable to that of natural regrowth and should be sustainable in terms of soil fertility. (19)

The Earth Institute is developing technologies and policy solutions to help ensure a sustainable energy future for all. We are developing the next generation of carbon capture and storage technologies, as well as working on questions related to renewable energy, solar energy, nuclear power and the conversion of solid waste into usable energy (20).

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