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Forestry and Climate Change: Mitigation & Adaptation

Indresh Kumar and S K Verma

Department of Agroforestry, College of Horticulture & forestry, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, UP

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Introduction

Global climate change is the burning issue of the present. Global climate change which is a result of an increase in global average temperature has been attributed to increased emission of greenhouse gases (GHGs).The major greenhouse gases include carbon dioxide (CO_2), methane, oxides of nitrogen and chlorofluorocarbons (CFCs). Among these CO_2 has been found to be the most responsible GHG contributing 78% of the total GHG

Hence, there is an urgent need to manage the atmospheric CO_2 through appropriate carbon sequestration technique. Carbon sequestration is a technique for the long-term storage of carbon dioxide or other forms of carbon, for the mitigation of global warming. Carbon dioxide is usually captured from the atmosphere through biological, physical or chemical processes. By considering these, several carbon mitigation strategies have been thought off and one among them is carbon sequestration through forests or trees.

Forests and carbon sequestration:

Forest ecosystems are especially important to the global carbon cycle in two ways

(i) They are responsible for cutting down about three billion tons of carbon every year which amounts to 30 per cent of all carbon dioxide emissions from fossil fuels.

(ii) Forest ecosystems are worldly carbon sinks in that they store large amounts of carbon which accounts for as much as double the amount of carbon in the atmosphere.

There are mainly three major strategy offered to mitigate carbon emissions through forestry activities:

i. Reducing carbon emissions that are caused from deforestation and degradation,
ii. Increasing the amount of forested land through a reforestation and aforestration process.
iii. Expanding the use of forest products that will sustainably replace fossil-fuel emissions for electricity and fuel.

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Trees as carbon sink:

Trees are considered as one of the important carbon sinks as they absorb CO_2 from the atmosphere through photosynthesis and storing it in its biomass. Trees (wood) contain approximately 50% carbon (dry weight) and increase in standing timber is directly correlated with increase in bound carbon.

CO_2 in trees or forests is released whenever land is converted to non-forest uses or troubled by logging, burning or outbreaks of pests and disease. All living trees both absorb and release CO_2, and the relative balance between the two processes determines whether a tree is a source or sink of CO_2. Trees are not the solution to global CO_2 rise, but they can be most effective in mitigating CO_2 emissions in the near term which climate scientists have identified as a crucial period if we are to avoid potentially calamitous changes in climate. Tree and stand growth rates vary considerably and hence carbon sequestration rates vary depending factors such as: stand type, stand age, site productivity/quality, stand density, as well as silvicultural inputs/treatments. Certain adaptive management interventions in enhancing tree and stand growth rates can also be useful in enhancing carbon sequestration through trees.

Approaches to enhance carbon sequestration through trees:

The goal of carbon storage through trees can be integrated with traditional goals such as water, soil conservation, wildlife, recreation and wood production. Thus, technologies which are adopted to meet such traditional goals can also be applied to enhance carbon sequestration through trees.

1. Afforestation and reforestation: Absorbing CO_2 from air and transferring it into the biomass could be a cost effective and practical way of removing large volumes of GHGs from the atmosphere. Some of the important primary ways through which afforestation and reforestation can increase *biosequestration* of carbon are as follows:

a. Increasing the volume or area of existing forest: Large chunk of land mass in the world is not under productive use which can be considered as wastelands. It is estimated that around 25 per cent of the total land area of the world is unproductive degraded and wasteland. Bringing considerable portion of such land under tree cover through appropriate afforestation and reforestation techniques could substantially increase the carbon sequestration through trees. For being afforestation and reforestation successful the species selection for specific site

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conditions is of paramount importance, because it not only determines the survival of plantation but rate of carbon sequestration also.

The silvicultural characteristics of the species to be planted should be well thought out which includes:

a. Fast growth rate / Short rotation species
b. Resistance to drought, diseases, insects and pests
c. Fire resistant species
d. High wood density species

b. Increasing the stand density or stocking in existing forests at a stand and landscape scale:

c. Establishment of mixed species plantations: Mixed plantations are more likely to support a greater level of structural, functional, and biological diversity, than a monoculture; and at the same time be more resistant to pest and disease outbreaks. A mix species planting is also likely to maintain a balanced soil nutrient budget, and therefore sustain long-term site productivity.

2. Genetic improvement for enhancing carbon sequestration: This recent approach to enhance carbon sequestration in trees includes use of quality seeds, clonal seedling and biotechnology. It is understood that carbon sequestration and carbon stock vary with genotype of individuals under specific environment. Use of individuals with best genotype among available genotypes can be of significant importance. In the recent past, the clonal forestry has gained much attraction of foresters because of short rotation. The selection of best genotype to enhance the productivity in plantation forests could play a pivotal role in carbon sequestration through trees also. Use of superior clones to prevent mortality caused by drought and pest is argued to be stock improving and climate mitigation.

3. Forest management interventions meant for boosting carbon sequestration and further preventing the release of the carbon dioxide: The Intergovernmental Panel on Climate Change (IPCC) concluded that a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber fibre or energy from the forest, will generate the largest sustained carbon mitigation benefit. Managing forests to sequester carbon has a combined advantage of producing woods and conserving biodiversity while preventing soil erosion. Hence, forest management practices tend to reduce CO_2 in the atmosphere through two different approaches:

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a. Maintenance of existing forests, thus addressing the source of emissions from the forest sector:

i. Forest management activities reducing deforestation and degradation of forests:

ii. Conservation of biodiversity through direct conservation of forests: Forest biodiversity is a key factor in maintaining ecosystem services and livelihood products provided by forests. Biodiversity in forests helps in effective utilization of site resources for the growth and development of trees and associated species in the forests which would enhance the carbon sequestration in trees and soils of the forests. Specific management interventions for maintaining biodiversity include the prevention of disturbances such as fire (managing fuel load, prescribed burning) or maintenance of their natural cycles, particularly in arid and semi-arid forest areas.

b. Increasing the rate of accumulation of carbon in the forest area:

i. Maintenance of fast growing short rotation crops: In fast growing species, when the rotation is shorter than the average life-span of the manufactured products there is a net sink effect provided by harvesting and manufacturing. Longer rotation will increase C storage; however, it may also reduce productivity and hence C sequestration rate being low.

ii. Tending operations: For establishment of the regeneration and subsequent development of the forest crop up to harvesting, several operations are carried out. These operations are carried out in order to provide a healthy environment for their development. These operations are called tending operations and include following:

- Weeding
- Cleaning
- Thinning
- Pruning
- Improvement felling

iii. Management of insect pests and diseases: Insect infestations can cause defoliation, partial or total tree mortality, reductions in forest CO_2 uptake in photosynthesis, and increases in emissions from the decay of biomass. Periodic insect and disease infestations have always been part of the natural cycles of growth, self-thinning, death and rejuvenation of forest stands. Climate change, mainly warmer winters, has contributed to the unprecedented extent and severity of the insect outbreak in tree species. Insect outbreaks represent an important

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mechanism by which climate change may undermine the ability of northern forests to take up and store atmospheric CO_2. Tree mortality from catastrophic outbreaks reduces forest carbon uptake and increases future emissions from the decay of killed trees.

iv. Fertilization: Fertilization of tree species increase the growth of trees which results from higher carbon storage in wood and other parts of trees. If the nutrients (N, P, K etc.) being applied is in short supply in the forest soil, it significantly reduces the growth rates and carbon storage in trees.

v. Harvesting methods: Harvesting method such as low impact harvesting methods, low carbon emitting logging techniques and harvesting in coup and allowing tree to grow for longer periods between harvests etc. are some important techniques to overcome the emission of CO_2 during harvesting. Selecting appropriate harvest regime so that conversion loss becomes minimized is one mitigation strategy in forest management.

Agroforestry:

Agroforestry is the practice of combining forestry production and agricultural production to derive synergistic benefits. It is a collective name for land use system and technologies in which woody perennials are deliberately combined with herbaceous crops and/or animals on the same crop management unit in some form of spatial arrangement, temporal sequence or both so that there are both economic and ecological interactions among the different components. The most common practices in Agroforestry are

1. Intercropping for the purpose of growing agricultural and forest products
2. Boundary and contour planting for wind and soil protection as well as for the provision of agricultural and wood products.

Urban forestry:

In the world, the most of carbon dioxide and other polluting gases are emitted to the atmosphere in urban areas from transportation and industries. If these gases are trapped by trees growing in the city, a part of polluting gases can be reduced. The main important aspect for this is to identify the tree species whose photosynthetic efficiency is higher and can be grown in harsh conditions of cities. Bio- sequestration of carbon through trees may be enhanced by urban forestry. Urban forestry can play a crucial role in mitigation of carbon in atmosphere which makes use of space in urban areas to increase carbon sequestration and reduce energy use for heating and air conditioning.