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Climate Change and India's Forests: Vulnerability, Adaptation Strategies and Mitigation role

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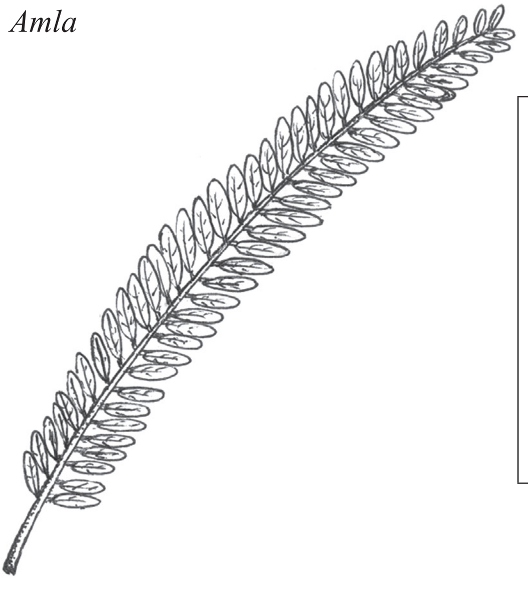
Amla



Phyllanthus emblica is a small to medium sized tree planted throughout tropical India and on the hill slopes up to 2000 meters. It has simple subsessile leaves closely set along branchlets, light green, resembling pinnate leaves. Fruit is nearly spherical and smooth and hard in appearance, with six vertical stripes or furrows. Regarded as the sacred tree in India it is considered to enhance spiritual purity. Amla fruits are a very rich source of vitamin C and are highly valued among indigenous medicines.

Introduction

As per Fifth Assessment Report of Inter-governmental Panel on Climate Change (IPCC), the global surface temperatures have risen by almost 0.89°C over the period 1901-2012 and about 0.72°C over the period 1951-2012, and it is extremely likely that the human activities have caused more than half of the observed increase in temperature during 1951-2012 (IPCC, 2013). The report has predicted that relative to the reference period of 1986-2005, the global surface temperature increase by the end of 2100 is likely to be in the range of 1.5°C to 4.5°C and in the range of 0.3°C to 0.7°C for the period 2016-2035. This would cause further warming and induce many changes in the global climate systems during the 21st century and will very likely be severe than those observed during the last century.

A scientific study from Indian Network for Climate Change Assessment (INCCA, 2010) on prediction of future climate for India has indicated an all round warming over the Indian sub-continent associated with increasing greenhouse gases (GHGs) concentrations. The study has projected a likely rise in annual mean surface air temperature by the end of the century in the range of 3.5°C to 4.3°C. The prediction also depicts that there may not be significant decrease in the monsoon rainfall in the future except in some parts of the southern peninsula. Further, impact assessment of future climate on water courses indicates that majority of river systems show an increase in precipitation at the basin level, and only the Brahmaputra, Cauvery and Pennar show marginal decrease in precipitation.

Forests provide a wide range of ecological, social and economic benefits, in the form of goods and services to society that are much less easier to quantify. In particular, forests provide livelihood and are especially important for the large number of forest dependent communities for numerous goods and services. However, forests are the most vulnerable climate dependent systems especially in the tropics, boreal and mountain areas. A report from the International Union of Forest Research Organizations (Seppälä *et al.,* 2009) paints a rather gloomy picture about the future of the world's forests in an era of accelerated climate change, as it suggests that in a warmer world the current carbon regulating services of forests as carbon sinks may be entirely lost as land ecosystems could turn into a net source of carbon dioxide later in the century.

According to the IPCC, roughly 20-30% of vascular plants on the planet are estimated to be at an increasingly high risk of extinction as temperatures increase by 2-3°C above pre-industrial levels (Fischlin *et al*., 2009). Even small changes in climate could affect phenological events such as flowering and fruiting that may escalate into major impacts on forest biodiversity. This is because co-evolution has produced highly specialized interactions among specific plant and animal species in natural forests. Vulnerability analysis of forest ecosystems in the Indian national communications demonstrates that climate change can significantly affect the availability of forest goods and services in terms of quality and quantity (MoEF, 2012).

Likely impacts of Climate Change on Forests of India

A study by Indian Institute of Science, Bangalore covering the entire forests of the country on analysis of the 35,190 forested grids reported that more than two-thirds of the forested grids are likely to undergo vegetation change by the year 2100. Almost all major forest types are likely to be impacted by the projected climate change. The actual impacts may be more as different species respond differently to the changing climate. A few endemic species may show a steep decline in population and may even get extinct. These impacts are expected to have adverse socio-economic implications for the forest-dependent communities and the economy of the country. Moreover, the impacts of climate change on forest ecosystems are likely to be long-term and irreversible. On the positive side, the study reports that the average net primary productivity is projected to increase by 1.5 times for tropical evergreen forests but the rate of increase is expected to be lower for temperate deciduous, cool conifer and cold mixed forests (Ravindranath *et al.,* 2006).

In another study, the likely impacts of climate change on forests of India have been assessed for two future time-frames i.e., 2021-50, labelled as '2035' during which atmospheric CO_2 concentration is expected to reach 490 ppm, and 2071-2100, labelled as '2085' during which atmospheric CO_2 concentration is expected to reach 680 ppm (MoEF, 2012). It is projected that about 30.6% of the forested grids are likely to undergo change in vegetation by 2035 and similar change is expected to the extent of 45.9% by 2085. Vulnerability assessment showed that the vulnerable forested grids are spread across India. However, their concentration is likely to be higher in the upper Himalayan stretches, parts of Central India, Northern Western Ghats and Eastern Ghats. In contrast, Northeastern forests, Southern Western Ghats and the forested regions of Eastern India are projected to be least vulnerable to the changing climate. The study has also shown that low tree density and biodiversity status as well as higher levels of fragmentation contribute to the vulnerability of forests (Gopalkrishnan *et al.,* 2011).

Pressures on Forest Resources

Approximately 275 million people in India are known to live in the forest fringes and earn bulk of their livelihood from forests (World Bank, 2006) and more than 40 per cent of the forests in country are degraded and under-stocked (Aggarwal *et al.,* 2009). There are a number of geographical, demographic and socio-economic factors responsible for this degradation. In addition to the fragile ecosystems, increasing population with low agricultural production, large and unproductive bovine population, degraded community forests and restricted means of livelihood constitute a vicious cycle of poverty resulting in tremendous pressure on forests in the country. Some major pressures on forests resulting in deforestation and forest degradation are discussed below.

Unregulated removal of wood: 853.88 million persons of our country use fuelwood as a source of energy for cooking or heating, out of which 199.63 million (23.38%) use fuelwood from forests. The total fuelwood consumption in the country is 216.42 million tonnes per year whereas forests can produce only 58.75 million tones of annual sustainable yield. The total annual consumption of wood other than fuelwood i.e., wood for construction, household furniture, and industrial furniture is 48.0 million m^3 which also comes from the forests (FSI, 2012). This demand along with informal removals exerts tremendous pressure on the forests of the country. Likewise, fuelwood accounts for 71% of the sources of domestic energy and is especially important to forest dwellers and rural people.

Diversion of forestland for non-forestry purposes: Forests are increasingly being diverted for purposes such as hydel power projects, industry, road buildings, and mining. Between 2009 and 2011, a total of 36,700 ha of forest land has been diverted for various developmental activities in the country ((FSI, 2012), of which a major part has been diverted for hydel power and mining projects. This is believed to have resulted in problems such as increased soil erosion and landslides.

Unregulated grazing: Grazing and trampling of regenerated seedlings by livestock is the biggest threat to regeneration of vegetation in all forested areas of the country. The National Biodiversity Strategy and Action Plan (GoI, 2002) has estimated that the requirement for green fodder is 1061 million tonnes and for dry fodder it is 589 million tonnes per annum. However, pastures in the common lands including forests, are a source of only about 280 million tonnes of fodder annually (Planning Commission, 2011). Most of this gap is filled by unregulated grazing, illegal removal such as heavy lopping of trees and cutting of saplings. Reduction in the size of pastures and closing of some pastures for tree plantation has resulted in even greater pressure on the remaining resources, especially along the forest fringes.

Unregulated collection of NTFPs including medicinal plant parts: The other major source of pressure on forest resources is the unsustainable harvesting of Non-Timber Forest Products (NTFPs) which also includes medicinal plants parts. A serious consequence of the low productivity of agriculture and livestock is the over-exploitation of NTFPs including medicinal plant parts to supplement low income. For example, extraction of medicinal plant parts in alpine meadows for sale has resulted in over-exploitation of several herb species (Uniyal *et al.,* 2002). Pressures are particularly high on high value medicinal plant parts such as Salampanja (*Orchis latifolia*), Kutki (*Picrorhiza kurroa*), Dhup (*Cynodon dactylon*) and Atis (*Aconitum heterophyllum*) in NW Himalayas.

Forest fires: Uncontrolled fires have caused tremendous damage to the forest biodiversity of the country. Forest fires generally spread in two phases – the first phase occurs during late March and early April when fresh leaf litter especially in Chir pine and dry deciduous forests gets accumulated and burnt. The second phase of fire, which occurs in May-June, is more serious. It occurs under conditions of high temperature, extreme dryness, strong winds, and low moisture in the forest floor.

Since the year 2005, Forest Survey of India (FSI) has been monitoring forest fires across the country using inputs received from Moderate-resolution Imaging Spectrometer (MODIS) satellite system. A total of 134,225 forests fires have been reported from 2004-2005 to 2010-2011 in the country out of which 43% fires covering an area of 208,348 km^2 have been observed in moderately dense forests, 40% fires covering an area of 161,856 km^2 have been observed in open forests and remaining over an area of 49,867 km^2 in very dense forests (FSI, 2012). Though reliable data is not available on loss of carbon, but this must be substantial.

Suggested Adaptation Measures

Adaptation measures are planned responses aimed at reducing the vulnerability of a system. Adaptation is an adjustment in human and natural systems in response to actual or expected climate stimuli or their impacts that moderate harm or exploit beneficial opportunities (IPCC, 2007). The need to include adaptation into forest management and policies is becoming increasingly recognized, especially in tropical and temperate areas. In particular, forest stakeholders face challenges related to understanding vulnerability, identifying adaptation options, and implementing adaptation strategies.

As discussed above, the forest ecosystems in India are already subjected to heavy socio-economic pressures leading to forest degradation, and climate change will be an additional pressure on these ecosystems. Climate change can significantly affect the availability of forest goods and services in terms of quality and quantity. Many non-timber forest products are likely to be more vulnerable to changes in climate system than timber and fuelwood production (Robledo and Forner, 2005), and hence would have a more profound impact on the forest-dependent communities depending upon NTFPs for their livelihoods.

Despite availability of projections on future climate parameters, there is no certainty about the likely impacts of climate change on the forests in India. Yet, it is imperative to begin developing adaptation strategies, based on observed changes elsewhere under similar ecological conditions. Some of the adaptation measures for the country's forests could be:

1. Identification of critical forest ecosystems and species and initiating measures that would reduce pressure on such ecosystems and species and ensure their conservation either through *in-situ* and *ex-situ* means.
2. Maintaining of proper health and hygiene of the forest ecosystems to reduce vulnerability to pests and diseases.
3. The State Forest Departments needs to strengthen the existing fire detection and management systems and work towards reducing the response time. Ensuring proper sanitation measures to prevent incidence of fire will also be very important.

4. Grazing being a State subject, the States need to come out with a policy on grazing, which should ensure no grazing in the plantation and natural regeneration areas. Grazing should be regulated and communities need to be encouraged to keep only productive livestock which could be stall-fed.
5. Incorporating climate change concerns in the working plans/management plans prescriptions to ensure that the prescriptions and management interventions are in line with adaptation measures.
6. To build the capacity of the forest department to understand the vulnerability of the forest ecosystems to the changing climate. In this context capacity building programmes focusing on forest ecosystems and their future management would be important.

Forest Sector and Climate Change

At global level, forest sector is one of the important sources of CO_2 emissions which accounts for 1.6 ± 0.8 GtC annually. This constitutes around 20% of the global CO_2 emissions (Ravindranath and Murthy, 2003). Deforestation, forest degradation, fragmentation and diversion of forest land for non-forest purposes are the main sources of CO_2 emissions and also the key issues in developing countries. At the same time, the forestry sector also offers large CO_2 mitigation opportunities for removal of accumulated CO_2 in atmosphere, and sequester it in vegetation and soil (Sharma *et al.*, 2003). Durable wood products also continue to lock carbon for varying periods extending upto 70-100 years or beyond. The removal of CO_2 from the atmosphere can be achieved at comparatively lower costs in the forestry sector when compared to other sectors such as energy, chemical industry, transport, agriculture and waste disposal. Moreover, the costs are likely to be still lower when sequestration activities take place in developing countries like India.

Global response to Climate Change

Expression of public concern over climate change issues began with the first World Climate Conference held in 1979 in Geneva (Switzerland). This led to the establishment of the Inter-governmental Panel on Climate Change (IPCC) in 1988. The IPCC issued its first assessment report in 1990 which confirmed that threat from climate change was real. This gave rise to adoption of the United Nations Framework Convention on Climate Change (UNFCCC) on 9th May, 1992, which opened for signatures during the Earth Summit. The Convention came into force on 21st March, 1994; with almost all countries as parties to the convention till date, it has become the most universally adopted Convention.

After about three years of hectic negotiations, a substantial extension to the Convention that outlined legally binding commitments was adopted at the third meeting of the Conference of Parties (COP 3), known as the Kyoto Protocol (KP), held in December, 1997. As per KP, industrialized countries were assigned legally binding emission reduction targets that amount to an aggregate reduction shared among all such countries of at least 5.2% from 1990 levels by the year 2008-12, known as the 'first commitment period'. The individual emission reduction targets for each country are listed in Annex B to the protocol. The KP was to enter into force, provided it was ratified by at least 55 parties to the convention, including enough industrialized countries to encompass 55% of that group's CO_2 emissions of 1990 level. These conditions ensured that no single party to the convention may block the entry into force of KP. The protocol was ratified with the signing by the Russian Federation and came into force on 16th Feb, 2005.

The Kyoto Protocol also provided three innovative mechanisms designed to boost the cost-effectiveness of climate change mitigation at global level by opening ways for the parties to cut emissions, or enhance carbon sinks, more cheaply abroad than at home. These mechanisms are: Joint

Implementation (JI), Emission Trading (ET) and Clean Development Mechanism (CDM). Out of the three mechanisms, only CDM is relevant to developing countries like India. The aim of CDM is that the industrialized countries would invest in 'clean' projects in developing countries; emissions reduced or removals increased through such CDM projects would be credited to them. CDM has been able to generate significant investment in developing countries, especially from the private sector to contribute towards objectives of UNFCCC, enhance the transfer of environment friendly technologies and promote sustainable development in general. Till date 7490 projects have been registered under CDM at global level out of which 1495 (19.95%) are from India. However, only 52 projects have been registered so far from forest sector at global level which constitutes only 0.54% of the total projects (UNFCCC, 2014). This includes nine forestry projects from India. The number of projects from forest sector is quite low due to several challenges being faced by the sector.

CDM forestry projects are limited to afforestation and reforestation (A&R). The carbon pools accepted under these projects are above ground biomass, below ground biomass, woody litter, dead wood and the soil organic carbon (UNFCCC, 2003). There is another important carbon pool which comes into play when a tree is harvested and wood products are made of it that have varying life spans. Carbon continues to be locked in such wood products during their life spans and benefits should accrue because of locked carbon. This carbon pool is known as harvested wood products (HWP) which being a contentious issue is under negotiation and benefits on account of this pool were not eligible for first commitment period, that expired on 31st December 2012.

Under CDM the emission offsets or removals are measured in tonnes of CO_2 equivalent and are known as Certified Emission Reductions (CERs). The CERs generated from CDM projects can be used by investing industrialized nations (Annex-I to UNFCCC also referred as 'Annex-I countries') to meet their own emission reduction targets. The CERs can be of three types, viz., normal CERs, temporary CERs (tCERs) and long term CERs (lCERs). Due to possibility of reversibility of additional C-pools generated out of forestry projects, the certified emission reductions generated from forestry projects are limited to tCERs and lCERs.

Requirements for Forestry CDM Projects

i) Definition of forest, afforestation and reforestation

Under the CDM, forestry projects come under LULUCF, i.e., land use, land use change and forestry. Terms like forest, afforestation and reforestation are defined in the CDM text as: *"Forest is a minimum area of land of 0.05-1.0 ha with tree crown cover (or equivalent stocking level) of more than 10-30% with trees with the potential to reach a minimum height of 2- 5 meters at maturity in-situ"*.

Each developing country was supposed to submit its own definition giving a value for minimum area, tree crown cover and minimum tree height within the range provided in the definition. India has already submitted its definition which is a minimum area of 0.05 ha, crown cover of more than 15% and minimum height of 2 m (UNFCCC, 2001). Therefore the definition of forest accepted by India is, *"Forest is a minimum area of land of 0.05 ha with tree crown cover (or equivalent stocking level) of more than 15% with trees with the potential to reach a minimum height of 2 m at maturity in-situ"*. This definition accepted and communicated by India requires that any land devoid of adequate tree cover, say agriculture, wasteland or degraded forest land will have to be either afforested or reforested on a minimum area of 500 m^2 with such trees which have a potential to reach a minimum height of 2 m at maturity and so densely planted that the crown cover reaches from less than 15% before the project to more than 15% during the CDM project activity.

Afforestation is defined as, *"the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-*

induced promotion of natural seed sources" (UNFCCC, 2001). This is relevant to agriculture, areas wastelands and other fallow lands which can be taken up for CDM A&R projects. Reforestation is *"the direct human-induced conversion of non-forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land'*(UNFCCC, 2001). For the first commitment period, reforestation activities were limited to reforestation occurring on those lands that were not classified as forests as per CDM definition as on 31.12.1989.

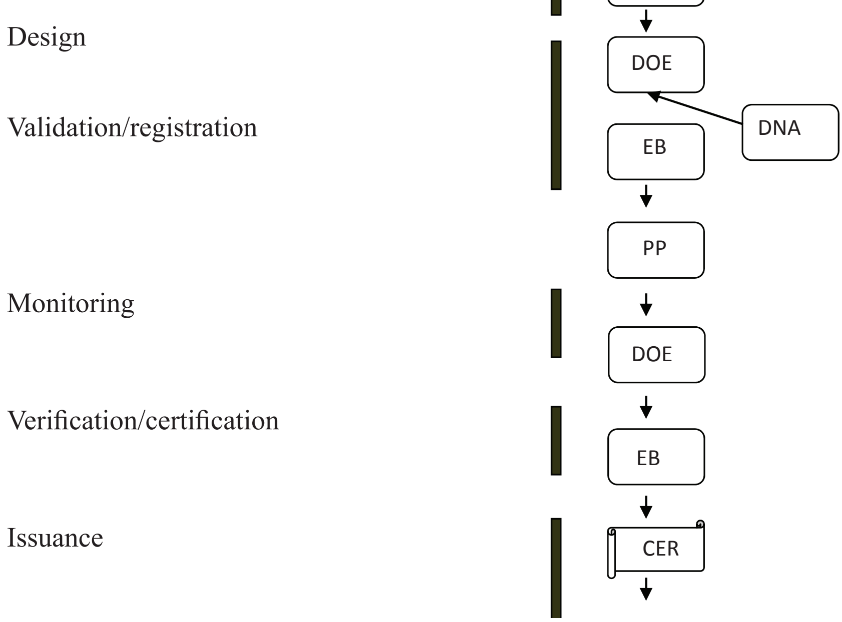
ii) CDM project activity cycle

Participants to the CDM project activity must prepare a Project Design Document (PDD), including a description of the baseline and monitoring methodology to be used, an analysis of environmental impacts, comments received from local stakeholders and a description of new and additional environmental benefits that the project is intended to generate (Fig. 1). An independent operational entity, also called 'Designated Operational Entity' (DOE), will then review this document and, after providing an opportunity for public comments, decide whether or not to validate it.

When a project is duly validated, the operational entity will forward it to the Executive Board of CDM for formal registration. Unless a participating party or three Executive Board members request a review of the project, its registration becomes final after eight weeks. Once a project is running, it will be monitored by the project participants. They will prepare a monitoring report, including an estimate of CERs generated by the project, and will submit it for verification by the DOE. To avoid conflict of interest, this will usually be a different DOE to that which validated the project. Following a detailed review of the project, which may include an on-site inspection, the DOE will produce a verification report and, if all is well, will then certify the emission reductions as real. Unless a participating party or three Executive Board members request a review within 15 days, the Board will issue the CERs and distribute them to project participants as requested (UNFCCC, 2003).

Fig.1

CDM project cycle



Small Scale CDM Forestry Projects

To reduce transaction costs, modalities and procedures are simplified for small-scale forestry projects under CDM. Small scale project activities under CDM are those activities that are expected to result in net anthropogenic GHG removals by sinks of less than 16 kilo tonnes of CO_2 annually and are developed or implemented by low-income communities and individuals. These small scale projects have been provided with some relaxations such as requirements of PDD have been reduced; simplified baseline methodologies are in place; Bundling of projects allowed for PDD; same DOE may undertake validation, verification & certification; monitoring plans are simpler; and leakage assessment is also simpler for these projects.

Important Issues in CDM Forestry Project Development

There are a number of issues which must be addressed, while formulating a forestry CDM project, important among these are Development of baseline, Non-permanence, Additionality and Leakage assessment.

i) ***Development of baseline*** – The baseline is the scenario that reasonably represents the anthropogenic emissions by sources of GHGs that would occur in absence of proposed CDM project activity. A clear and verifiable baseline scenario giving C-stock changes in 'without project' situation needs to be presented using approved methodologies. The baseline is a status of carbon pools in the absence of project, which could be static or dynamic depending upon the situation. To date 11 approved methodologies exist for large scale and 7 for the small scale forestry projects.

ii) ***Non-permanence*** – This is concerned with the durability of C-stocks in forestry CDM projects. Non-permanence is a serious issue due to a possibility of reversibility in C-stocks due to anthropogenic or environmental changes. The issue of non-permanence is addressed for LULUCF project activities by accounting for emission reductions as temporary CER (tCER) or long term CER (lCER). A tCER expires at the end of the commitment period following the one during which it was issued which can be taken as five years, while a lCER expires at the end of the crediting period for which it was issued (UNFCCC, 2004). Both tCERs and the lCERs are likely to command lower prices compared to the permanent CERs because on expiry of non-permanent CERs, the buyer will have to arrange for the replacement accordingly.

iii) ***Additionality*** – This requires that C-stocks accrued to a C-sequestration project are "additional" to those that would occur in the absence of the project. One may argue that agroforestry plantations with good financial returns are a well recognized "business as usual" practice and cannot be treated as additional. However, enabling conditions for a successful agroforestry project may not exist in most of the areas and a project that facilitates such conditions can qualify as a CDM project. Tools for demonstration and assessment of additionality in A&R CDM projects are available. As per these tools, the proposed A&R project activity should not have taken place except for CDM benefits. The project activity should not be financially most attractive and if so, proper barrier analysis will have to be carried out to prove that the project activity is additional.

iv) ***Leakage assessment*** – Leakage is the increase in GHG emissions by sources which occur outside the boundary of the project activity but are measurable and attributable to the project activity. The project should also demonstrate how leakage issue will be addressed to ensure sustained carbon benefits. The project areas dedicated to common lands may have substantial leakage compared to agroforestry plantations as these lands may not be yielding woody biomass prior to their use as agriculture lands. The possibility of leakage is very high on lands which are being used for biomass removal before the CDM project activity.

Carbon Sequestration Potential of Tree Plantations

The types of forestry activities (afforestation & reforestation) eligible under CDM include planting of wastelands, agroforestry, farm forestry, planting of orchards and other plantation activities. There is enough evidence to show that individuals and communities can use tree plantations sustainably to support livelihoods besides carrying out agricultural and horticultural activities. The carbon benefits associated with such plantations could be additional returns to the growers. The available reports on the amount of carbon stored and likely carbon benefits for different plantation models is given in Table 1 (Gera *et al.*, 2006; Gera *et al.*, 2011a, b).

Table 1

Carbon Sequestration potential and likely Carbon benefits for different tree plantation models

Tree plantation model	Annual incremental carbon sequestered (tC/ha/yr)	Annual incremental carbon sequestered (tCO_2/ha/yr)	Likely carbon benefits (Rs/ha/yr)
Trees Species of Commercial importance			
Poplar block	2.54 (4.42)*	9.3 (16.22)	2790/- (4866/-)
Poplar bund	1.42 (2.46)	5.21 (9.03)	1563/- (2709/-)
Eucalyptus bund	1.62 (2.15)	5.95 (7.89)	1785/- (2367/-)
Horticulture Tree Species			
Apple block	0.75	2.77	831/-
Pear block	0.73	2.67	801/-
Plum block	0.19	0.68	204/-
Mango block	1.15	4.21	1263/-
Tree species of Medicinal importance			
Amla (*Emblica officinalis*) block	0.90	3.30	990/-
Bahera (*Terminalia bellirica*) bund	2.93	10.75	3225/-
Harar (*Terminalia chebula*) bund	2.30	8.44	2532/-
Reetha (*Sapindus mukorossi*) bund	2.60	9.54	2862/-
Long Rotation of Tree Species			
Pine	4.81	17.65	5295/-
Pine-Oak Mixed	3.69	13.53	4059/-
Mixed species*	3.99	14.65	4395/-

* With wood products; Carbon price = \$5/tCO_2; \$1=Rs 60/-

It is evident that the tree plantation models, viz., tree species of commercial importance; horticulture tree species; tree species of medicinal importance, and long rotation tree species show a wide range of sequestration potential, which varies from 0.19 tC/ha/yr in case of Plum block plantation to 4.81 tC/ha/yr for Pine block plantation. The sequestration potential depends on the MAI of wood growth, i.e., above and below ground, in terms of t/ha/yr. Though woody litter and soil organic carbon also have been taken into account for these calculations, their contributions have been observed to be small and rather negligible in certain cases as compared to wood growth by the authors. Higher the MAI, higher will be the sequestration potential, provided there is no harvest during the project period. In case of harvest during the analysis period, the carbon pools get adversely impacted due to IPCC default approach (IPCC, 2003), which says that the moment trees are harvested, the equivalent CO_2 is deemed to have been emitted in to the atmosphere.

The sequestration potential as reported for fast growing tree species, varied from 1.42 tC/ha/yr in case of Poplar bund plantation to 2.54 tC/ha/yr for Poplar block, whereas, Eucalyptus bund plantation recorded a sequestration potential of 1.62 tC/ha/yr. The reason for comparatively lower sequestration potential recorded for these seemingly fast growing tree species is attributed to their shorter rotations leading to loss of carbon on every harvest carried out during the period of analysis. For example, Poplar is grown with a rotation of six years, which is supposed to be harvested five times during the CDM project period of analysis, which was taken as 30 years.

The sequestration potential reported for horticulture species is quite small except for Mango, which is 1.15 tC/ha/yr. The development of carbon sequestration projects squarely involving these species may not be feasible because of low wood productivity of these plantations resulting in lower rates of carbon sequestration.

The sequestration potential reported for tree species of medicinal importance varied in the range of 0.90 tC/ha/yr for Amla (*Emblica officinalis*) block plantation to 2.93 tC/ha/yr for Bahera (*Terminalia bellirica*) bund plantation, whereas, Harar (*Terminalia chebula*) and Reetha (*Sapindus mukorossi*) showed a sequestration potential of 2.30 and 2.60 tC/ha/yr, respectively. The reason for significantly higher potential from seemingly slow growing NTFP species may be attributed to comparatively longer rotations (30-50 yrs) and no harvest during the project period.

Interestingly, plantation interventions dedicated for long rotation crops on forest lands, viz., Oak-Pine-mix, Mixed species and Pine recorded higher sequestration potential in the range of 3.69 tC/ha/yr for Oak-Pine-Mix block to 4.81 tC/ha/yr for Pine block plantation, whereas, mixed species plantation showed a sequestration potential of 3.99 tC/ha/yr. The higher sequestration potential is attributed to long rotation of the selected interventions coupled with no wood harvest, during the project period. Ravindranath *et al.* (2007) gave a sequestration potential for long rotation crops under Indian scenario in the range of 5.0-5.97 tC/ha/yr, which is comparable with the present estimations. Similarly, Makundi and Sathaye (2004) reported a sequestration potential of 3.27 and 4.8 tC/ha/yr respectively for long rotation plantations and temperate forest management under a scenario where crops are not harvested during the analysis period.

As already stated, the carbon benefits on account of sequestration directly depend on the sequestration rate per unit area per unit time. These benefits have been calculated at the carbon price of $5/tCO$_2$. The carbon benefits as estimated for plantation interventions involving horticulture species have been observed to be small and vary from Rs. 204/ha/yr for Plum to Rs. 1,263/ha/yr for Mango block plantation. This is obviously due to very slow woody growth of the horticulture crops coupled with regular hedging of plants for new branches. Among the interventions involving long rotation crops, Pine block showed the maximum carbon benefits (Rs. 5,295/ha/yr) on account of its moderate growth but long rotation and no harvest during the analysis period. Other similar interventions, viz., mixed species and Oak-Pine block also recorded comparable higher benefits of Rs. 4,395/ha/yr and

Rs. 4,059/ha/yr respectively. The likely carbon benefits for the plantation interventions involving tree species of medicinal importance, viz., Bahera, Harar and Reetha are also significant and range between Rs 990/ha/yr for Amla block to Rs 3225/ha/ya for Bahera bund.

The fast growing tree species in the present study, however, have registered higher sequestration potential when the harvested wood products are also included in the sequestered carbon pools. The species which are harvested earlier, like Poplar, start giving wood products immediately after harvest and the carbon pool, because of wood products, starts growing with every harvest and adds to the total carbon sequestered pool. Therefore, Poplar has recorded maximum increase with wood products as compared to the sequestration levels without wood products. Accordingly, the carbon benefits are significantly higher for Poplar block plantation if wood products are also included in estimation of sequestration levels.

India's Forestry CDM Experience

As per earlier estimates, the annual global demand for certified emission reductions during 2008-2012 was estimated to be around 250 million tonnes of CO_2 (Haites, 2004). Out of this demand, a significant portion could have originated from forestry projects and it was expected that the country would earn significant revenues from forestry CDM projects during 2008-12. However, experience on ground had been dismal wherein real demand never increased for CERs from forest sector and carbon price remained subdued and later declined to even less than a dollar per tonne of CO_2. This has dampened the enthusiasm to develop forestry CDM projects in the country and elsewhere. The challenge has been further compounded by the fact that the likely demand for CERs from forestry projects is expected to be much lower during second commitment period due to very few countries deciding to continue with the KP. Despite these challenges, our country has registered nine forestry projects under CDM which is 17.31% of total 52 forestry projects registered at global level till date. Brief details of registered projects from India are given in Table 2.

Table 2

CDM Forestry Projects Registered from India

Sl. No	Title of Project	Project location	Date of registration	Reduction per annum	Project area (ha)	Species selected	Choice of CERs	Crediting period (years)	C-Pools chosen
1	Small Scale cooperative afforestation CDM Pilot Project activity on private lands affected by Shifting Sand Dunes in Sirsa Haryana	Sirsa, Haryana	23.03.2009	11, 596 (s.s.project)	369.5	*Ailanthus excelsa Acacia tortilis, Eucalyptus* hybrid, *Acacia nilotica, Dalbergia sissoo, Zizyphus mauritiana Prosopis cineraria*	tCER	20 yr	AGB,BGB
2	Reforestation of severely degraded lands in AP under ITC SF project	14 Mandals in Khammam, A.P.	05.06.2009	57,792	3070.19	*Eucalyptus tereticornis, Eucalyptus camaldulensis*	ICER	30 yr	AGB,BGB
3	The International Small Group and Tree Planting Program (TIST), Tamil Nadu, India	3 Distt. of T.N i.e. Kancheepuram, Truvannamalai & Thiruvallur	15.01.2010	3,594 (s.s.project)	106	*Casuarina equisitifolia, Eucalyptus* species, *Tectona grandis*	tCER	30 yr	AGB,BGB
4	Improving rural livelihoods through C-sequestration by Adopting Environment Friendly Technology based Agroforestry Practices	3 Distt. in Orissa, i.e., Koraput, Kalahandi & Rayagada and 3 in A.P. i.e., Visakhapatnam, Vizianagram & Srikakulam.	28.02.2011	4,896 (s.s.project)	1607.7	*Eucalyptus* species, *Casurina equisitifolia,* Clonal *Eucalyptus*	tCER	30 yr	AGB,BGB
5	India: H.P Reforestation Project-Improving Livelihoods and Watersheds	Project located in 177 GPs in 11 watershed divisions of MHWDP of H.P.	04.03.2011	41,400	4003.07	45 tree species mainly local species	tCER	20 yr	AGB,BGB & SOC

Sl. No	Title of Project	Project location	Date of registration	Reduction per annum	Project area (ha)	Species selected	Choice of CERs	Crediting period (years)	C-Pools chosen
6	Begepalli CDM reforestation program	5 taluks of chick-ballapur distt. of Karnataka	27.05.2011	92,103	8933.34	Tamarind, Mango, Ber, Cashew etc.,	ICER	20 yr	AGB, BGB
7	Reforestation of degraded land in MTPL in India	Distt. in Orissa i.e. *Nabarangpu*r, Koraput, Malkangiri, A.P.-Vijayanagaram, Srikakulam & in Chhattisgarh-Bastar	01.08.2011	146,998	14,969	*Eucalyptus tereticornis*	tCER	30 yr	AGB, BGB & SOC
8.	Agro-forestry Interventions in Koraput district of Orissa	Jeypore , Kun-dra, Kotpad, Boipariguda and Boriguma blocks of Kora-put district	19 Nov 2012	1130	380.2	*Eucalyptus* clones *(Eucalyptus camaldulensis* and *Eucalyptus tereticornis)*	tCER	30 yr	AGB, BGB & SOC
9.	Rehabilitation of Degraded Wastelands at Deramandi in Southern District of National Capital Territory of Delhi through Reforestation	Dera Mandi/ South Delhi/ Delhi	30 Jan 2013	12,138	358.5	*Acacia leucopholea, Acacia nilotica, Prosopis juliflora, Prosopis cineraria, Acacia tortilis, Albizzia lebbek, Tamarindus indica, Syzygium cumini, Ficus* spp.*, Ailanthus excelsa, Butea monosperma, Dalbergia sissoo, Azadirachta indica, Zizyphus muaritiana*	tCER	30 yr	AGB,BGB

Challenges Faced by Forestry CDM Projects

Apart from complex modalities and procedures for developing and processing of CDM forestry projects, there have been several other challenges associated with the projects from forest sector. First and the foremost would be binding the growers for a pre-decided raising of a tree crop requiring a waiting period ranging from 6-20 yrs or even longer, for which they may not be prepared unless there are assured recurring benefits. It is therefore necessary to create enabling conditions that ensure a flow of project induced benefits. For example, farmers may prefer raising of horticulture crops such as Mango or Litchi, hoping to get continuous flow of recurring benefits rather than going for a long rotation timber yielding tree species associated with lower recurring returns and long rotation.

Another major hindrance to the development of forestry CDM projects involving small farmers is transaction cost, which includes cost of project development, validation, implementation, monitoring, verification & certification along with the CER issuance fee. In addition, costs may be incurred on development of baseline, consultation and involvement of different stakeholders, socio-economic and environment impact assessment, time and effort spent in search, negotiation and for finalizing the deal. Transaction costs in forestry CDM projects are higher in case the plantations are spread over a large number of patches. Even one project involving plantation on 1,000 ha of land may involve 500 to 1,000 small patches of plantations which are required to be monitored and later verified for issuance of CERs. This requires larger statistical sample for monitoring resulting in even higher transaction costs.

The most important hindrance to forestry CDM projects has been the limited market demand for non-permanent CERs issued under these projects. Moreover, being non-permanent they are traded at a heavy discount compared to normal CERs. This has resulted in a situation where virtually no market exists for CERs generated from forestry projects and buying of these credits had been limited to by the agencies like 'Biocarbon Fund' or by way of investment by private entities.

Second Commitment Period of Kyoto Protocol (2013-2020)

During the first commitment period, 42 developed countries (Annex-I countries) were assigned legally binding GHG emission reduction to an average of 5.2% of 1990 levels. During the second commitment period, developed country parties are committed to reduce GHG emissions by at least 18% below 1990 levels in the eight-year period from 2013 to 2020. For second commitment period, Annex-I countries may also choose to account for GHG removals by sinks resulting from 'forest management' besides Afforestation and Reforestation. However, forest management project activities undertaken under CDM projects shall not exceed 3.5% of the base year GHG emissions excluding LULUCF. While accounting for forest management, Annex-I countries shall demonstrate methodological consistency between the reference level and reporting including in the area accounted for, in the treatment of harvested wood products.

Emergence and Development of REDD-plus

Deforestation and forest degradation are not only contributing to climate change but also have severe adverse impacts on a wide range of important products such as timber, fuelwood, paper, food, and fodder as well as various ecosystem services like protection of soil and water resources, conservation of biological diversity, carbon sequestration and several other services provided by forests. Most of this deforestation and forest degradation is taking place in developing countries where millions of households depend on goods and services provided by forests. These constitute an important source of livelihood and safety net for rural poor. In view of the highly significant environmental, social and economic potential of forests, the forestry sector can make significant contribution to a low-cost global climate change mitigation portfolio that provides synergies with adaptation to climate change and sustainable development. To address these issues, a forest based climate change mitigation option named 'REDD' (Reducing emissions from deforestation and forest degradation), was initiated in 2005 in Montreal during the 11th Conference of the Parties (COP-11) negotiations for a post-Kyoto climate change regime, through a submission from Costa Rica and Papua New Guinea on behalf of the Coalition of Rainforest Nations. Subsequently, during COP-12 in Nairobi, India's proposal of including the compensation for conservation of forest under the umbrella of forest based mitigation measures was accepted and became the part of further negotiations.

The 'Bali Action Plan' agreed during 13th session (COP-13) held in Bali, laid the foundation of subsequent negotiations on the scope of this forest-based mitigation mechanism by consideration of policy approaches and positive incentives on issues relating to REDD. The nations affirmed the urgent need to take further meaningful action and decided on a two-year time frame to discuss the REDD framework. As a result, the 'Copenhagen Accord' agreed during the COP-15 not only recognized the crucial role of reducing emission from deforestation and forest degradation but also acknowledged the role of conservation, sustainable management of forests and enhancements of forest carbon stocks in developing countries, which is referred to as 'REDD-plus'.

A substantial improvement on REDD-plus was made in Cancun at COP-16, which set out the broad scope of REDD-plus in line with 'Bali Action Plan'. The developing country parties were encouraged to contribute to mitigation actions in the forest sector by undertaking the following REDD-plus activities, viz., (a) Reducing emissions from deforestation; (b) Reducing emissions from forest degradation; (c) Conservation of forest carbon stocks; (d) Sustainable management of forests; and (e) Enhancement of forest carbon stocks, as deemed appropriate by each party and in accordance with their respective capabilities and national circumstances.

The countries aiming to undertake these activities were to develop a national strategy or action plan, a national forest reference emission level and/or national forest reference level, a robust and a transparent national forest monitoring system. The agreement specified the implementation of REDD-plus in three phases; outlined the financing of REDD-plus through voluntary funds; and the promotion and support of social and environmental safeguards. The safeguards included prevention of negative impacts such as the conversion of natural forests and to promote the protection of biodiversity and ecosystem functions, ensuring full participation and sustainable livelihoods, the addressing of gender issues, and respect for the knowledge and rights of indigenous peoples, as enshrined in the United Nations Declaration.

The climate change talks in Durban (COP-17) centered around four key areas of REDD-plus, i.e., finance, safeguards, reference levels, and measuring, reporting and verifying (MRV) of carbon emissions from forest activities. Significant progress on reference levels, and MRV was achieved with decisions on how to set reference emissions levels, and defining how to measure emission reductions stemming from forestry initiatives. However, the achievements on safeguards and REDD-plus financing, despite many deliberations, has been below expectations due to the weak decision on social and environmental safeguards for the program, and no advances on sources of long-term funding except setting up of 'Green Climate Fund', which had no real or promised money.

During COP-18 at Doha, it was decided to undertake a work programme to scale up and improve the effectiveness of REDD-plus finance by (a) transfer payments for results-based actions; (b) incentivize non-carbon benefits; and (c) improve the coordination of results-based finance. In the recently concluded COP-19 at Warsaw in November 2013, Governments have shown their firm commitment to reduce emissions from deforestation and forest degradation by delivering a set of seven decisions collectively termed as the 'Warsaw Framework' for REDD-plus. The significant set of decisions comprises decisions on results-based finance to progress the full implementation of the activities; guidelines and procedures for the technical assessment of submissions from Parties on proposed forest reference emission levels and/or forest reference levels; modalities for measuring, reporting and verification (MRV); dissemination of information on safeguards; modalities of forest monitoring systems; institutional arrangements; and addressing drivers of deforestation. These decisions provide guidance for ensuring environmental integrity and pave the way towards full implementation of REDD+ activities on the ground. The 'Warsaw Framework' was also backed by pledges of US $280 million financing from the US, Norway and the UK to support developing nation actions to progress the full implementation of the activities under REDD-plus.

Issues and Challenges of REDD-plus

The REDD-plus framework is confronted with important issues centered on the design, scope and financing needs; its cost effectiveness; measuring, reporting, and verification (MRV) of carbon emissions from forests, and social and environmental safeguards. Some of the other important issues such as insuring several co-benefits of reducing emissions from forests and the definitions of important elements of proposed REDD-plus mechanism have not been addressed so far. These issues are still being debated, and the actual design and framework of REDD-plus has yet to take a final shape. Some of these important issues and challenges being faced by REDD-plus are discussed below.

i) Design and framework for REDD-plus

It is not yet decided whether REDD-plus will be a part of the existing UNFCCC mitigation architecture or it will be part of a new universal climate agreement to be finalized by 2015 for post-2020 period. Another key issue is whether Afforestation and Reforestation, currently part of the CDM under the Kyoto Protocol, would be merged with REDD-plus in a comprehensive forest sector accounting framework.

ii) Financing REDD-plus

The financing mechanisms for REDD-plus have to be flexible and innovative, so that it can adapt to countries' changing needs and experiences. REDD-plus funding is required in three areas, viz, (i) up front investments in REDD-plus readiness activities like infrastructure, forest monitoring systems, capacity building and demonstration activities; (ii) ongoing costs of implementing national policies and measures; and (iii) compensation payments to forest owners for forgone profits (Dutschke *et al.,* 2008). The desired funding to exploit the REDD-plus potential can be arranged through Official Development Assistance and other forms of public funding for countries with restricted access to REDD-plus global mechanisms. The other option is a market-based mechanism that would trade CERs similar to the CDM in an "offsets" market in which industrialized nations can purchase emission credits to offset their emissions and thus meet their respective emissions reduction commitments.

iii) Setting the reference level for REDD-plus payments

There are three types of the baselines emerging in the current debate. These are: (i) the historical baseline, that is, the rate of deforestation and degradation (DD) and the resulting GHG emissions over the past x years; (ii) the projected business-as-usual (BAU) scenario, that is, how would emissions from DD evolve without the REDD-plus activity, and (iii) the crediting baseline, that is, the level at which REDD-plus payments should start (Angelsen, 2008). A BAU baseline is the benchmark for assessing the impact of REDD-plus measures that were implemented (and ensuring additionality), whereas the crediting baseline is the benchmark for rewarding the country (or project) if emissions are below that level. Almost all submissions from different countries use historical deforestation as the point of departure, and most also recommend that 'national circumstances' and 'rewarding early action' be taken into account. These principles still have to be put into practice.

A key dilemma facing negotiators is that, on the one hand, generous baselines, based on 'country-by-country' assessments that take national circumstances into account, may create 'tropical hot air', which undermines the environmental integrity (overall emissions reductions) and the credibility of REDD-plus (Angelsen, 2008).. On the other hand, too-tight crediting baselines may make an agreement unacceptable. In short, the balancing act between the risk of 'tropical hot air' and the participation and political acceptance of REDD-plus by countries is likely to be the key to success.

iv) Measuring, Reporting, and Verification (MRV) of carbon emissions from forests

This is concerned with different forest monitoring technologies and the trade-offs between the different methods. There are two main methods for measuring C-stocks: (i) the stock-difference approach, which measures forest carbon stocks at different points in time, and (ii) the gain-loss approach, which estimates the net balance of additions and removals from the carbon pool. There is a trade-off between the cost and the accuracy of the methods. In some countries, the need for a high level of precision requires the use of fine-resolution remotely sensed data to detect forest degradation or small-scale deforestation, which comes at a cost. Similarly, ground measurements, crucial to verify and measure carbon stocks, are time consuming and relatively expensive at a large scale, such as a national inventory.

As the capacity of countries to carry out MRV is highly variable, a global REDD-plus scheme must be flexible enough to avoid discrimination against countries with poor MRV capacity. A phased approach is recommended to allow for capacity building, to let countries gain experience, and to eventually integrate them into a performance-based payment mechanism in a future climate regime. Incentives should be put in place that encourage more accuracy and efficiency, and provide support for capacity building. To overcome national capacity and cost constraints, the option of centralized monitoring by an international institution can also be explored (Wertz-Kanounnikoff *et al*., 2008).

v) Achieving REDD-plus co-benefits

Co-benefits is the reason why REDD-plus has claimed substantial attention in international climate negotiations. It has the potential to alleviate poverty, protect human rights, improve governance, conserve biodiversity, and provide other environmental services, i.e., co-benefits, as well as reduce GHG emissions. Each co-benefit is required to be linked with specific design features of REDD-plus at the global and national levels so that the co-benefits can be achieved without undesirable consequences. Integrating REDD-plus into mainstream economic development strategies is important to benefit the poor and lead to performance-based payments, data transparency and financial accountability. Further, international scrutiny could exert a positive influence on human rights and governance. In addition, biodiversity benefits can be enhanced by geographically targeting vulnerable areas (Brown *et al*., 2008).

India's Stand on REDD-plus

The submission from Ministry of Environment & Forests, Govt. of India on REDD-plus provides a framework of approach to develop and implement a national REDD-plus strategy and actions pursuant to relevant COP decisions for assessment and monitoring of forest carbon stocks. India's national strategy aims at increasing and improving the forest and tree cover of the country for enhancement of forest ecosystem services that flow to the local communities. The services include fuelwood, timber, fodder, NTFP and also carbon sequestration. The country recognizes that carbon service from forest and plantations is one of the co-benefits and not the main or the sole benefit.

Initiatives like Green India Mission (GIM) and National Afforestation Programme (NAP), together with programmes in sectors like agriculture and rural development are expected to add or improve 2 million ha of forest and tree cover annually in the country. With a conservative sequestration level of 1tC per ha, this would annually add 2 million tonnes of carbon incrementally, and post 2020, the forest and tree cover will be adding at least 20 million tonnes of carbon every year. This would require an annual investment of Rs. 90 billion for 10 years. The country expects a substantial part of this investment to be met under REDD-plus financing from different sources including UNFCCC (MoEF, GoI). The Government of India may also initiate a process under various schemes such as NAP, CAMPA and GIM to reward the conservation efforts of the community with the parameter of enhancing carbon and associated ecosystem service.

i) Institutional mechanism for REDD-plus at national level

The Government of India has established a 'REDD-plus Cell' in the Ministry of Environment and Forests having the task of coordinating and guiding REDD-plus related actions at the national level, and to discharge the role of guiding, and collaborating with the State Forest Departments (SFDs) to collect, process and manage all relevant information and data relating to forest carbon accounting. The National REDD-plus Cell is to also guide formulation, development, funding, implementation, monitoring and evaluation of REDD-plus activities in the States. The Cell is also expected to assist the MoEF and its appropriate agencies in developing and implementing appropriate policies relating to REDD-plus implementation in the country.

ii) National level forest carbon stocks accounting

The forest carbon stock accounting at national level has been institutionalized by making Forest Survey of India (FSI) as the lead institution for the country, which will have a networking approach involving other national level institutions, viz., Indian Council of Forestry Research and Education (ICFRE), Indian Institute of Remote Sensing (IIRS), Indian Institute of Science (IISc), Wildlife Institute of India (WII), and any other organization that FSI deems fit to co-opt. India intends to further work on (i) technological and methodological issues, and (ii) policy and definitional issues to be able to contribute proactively in the future deliberations of the UNFCCC on REDD-plus.

The forest carbon stocks of the entire country will be compiled at the national level, and will comprise such stocks corresponding to the forest cover of the country and trees outside forest in the country. These stocks once accounted for in the First Accounting Period shall continue to be accounted for in the subsequent Accounting Periods also. The country also advocates that the reference emission level/reference level shall be fixed in an open and transparent manner following the procedure agreed for the purpose, which will include independent expert review by UNFCCC.

iii) Methodological issues

India's future strategy in this regard is to devolve more and more responsibility on the SFDs to carry out the assessment and estimation of forest carbon stocks (FCS) in conjunction with the biennial exercise of assessment of forest and tree cover (FTC). This is considered essential to improve the precision level for estimation of FCS as the State Governments can cover more sample points than that being covered by the FSI at present due to constraints of time, finances and inadequate number of technical experts. In future, the SFDs can take the responsibility of carrying out the inventories for FCS and FTC by more effectively utilizing the services of their Remote Sensing Application Centres. FSI at that time can act as the source for providing remotely sensed data required by the States for the purpose of carbon accounting.

iv) Definitional and Policy issues

Government of India has proposed that the terms which are being used in REDD-plus text, like deforestation, forest degradation, conservation, sustainable management of forests, enhancement of forest carbon stocks, national forest reference level/nation forest emission reference level, and others should be clearly defined. More insight into understanding the definition of sustainable management of forest (SMF) is required to steer its proper application in forestry mitigation actions in different parts of the country. In ensuring the safeguards for the rights of the local communities including tribal's, and above all, of women folk of the local communities, India intends to involve civil society and SFDs in working out provisions and modalities for the same under the extant Forest Rights Act, and approaches of Joint Forest Management.

v) National forest reference level

India gives highest priority to fixing of the reference level for carbon stocks in its forest and tree cover for measurements, verification and reporting of baseline and incremental forest carbon stocks. The country considers that the reference level in essence will be a baseline forest carbon stocks position corresponding to a specific year, which may be called the 'zero year' and needs to be fixed with consensus amongst intra-country stakeholders that would include the Central Government, State Governments, forest experts, scientists, local communities and the civil society. It is presumed that the starting point for fixing a forest reference level will be an agreement on the 'zero year' backed by sound logic, time series of scientific historical data, and milestones of relevant legislation and policy prescriptions.

vi) Social and environmental safeguards

Developing countries are expected to follow safeguards, with a view to ensure full participation of indigenous peoples including tribals, local communities, women and other stakeholders, and conservation of natural forests and biodiversity in implementing the REDD-plus activities. India intends to ensure that all REDD-plus incentives available from international sources will flow fully and adequately to the local communities which participate in management of forest resources or are dependent on them for sustenance of their livelihood. A part of the incentives are also expected to be invested in conservation and improvement of the ecosystem services like biodiversity and non-timber forest produce.

vii) Financing mechanism for REDD-plus

As per provisions of REDD-plus mechanism, the countries need to explore financing options for full implementation of the results based actions. India has reiterated its position of favouring a flexible combination of market and non-market based financing approaches. The country proposes a market based approach for fluxes with respect to a reference level for actions viz., (a) Reducing emissions from deforestation; (b) Reducing emissions from forest degradation; (c) Sustainable management of forest; and (d) Enhancement of forest carbon stocks; and a non-market based approach for stocks with reference to actions viz., (e) Conservation of forest carbon stocks; and (f) Sustainable management of forests.

The Way Forward

During the conference of parties held in Durban (COP-17), the Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP) was established to develop a protocol, another legal instrument or an agreed outcome with legal force under the Convention, applicable to all Parties for post-2020 implementation. The ADP is to complete its work as early as possible, but no later than 2015, in order to adopt this protocol, legal instrument or agreed outcome with legal force. As the negotiations become increasingly complex, fundamental differences continue to grow and separate various coalitions of nations. Groups have yet to resolve central issues such as the magnitude of national emissions commitments; the means of implementation – particularly finance, technology transfer and capacity building; agreement on basic principles – common but differentiated responsibilities, equity, and historical responsibility; and whether the ultimate agreement will be legally binding.

The post-2020 agreement faces daunting, substantive and procedural challenges. Indeed, limiting global temperature rise to 2°C would require major emitting nations to reduce emissions by 50-80% by 2050. Many, including rapidly growing developing countries, are unwilling to accept such stringent targets, In addition, estimates of the financial aid required to assist developing countries are expected to rise from hundreds of billions of dollars per year in the near future to trillions of dollars per year by 2050. In such a complex situation, it seems that the ultimate climate agreement is more likely to reflect bottom-up pledges based on national priorities and circumstances rather than a forced, top-down reconciliation designed to meet nonbinding, aspirational global goals to cut down emissions. The forest sector, however, has gained importance during the last several years because of 'REDD-plus' framework which is likely to remain at centre stage and from an important component of post-2020 climate change regime.

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