5th K.P. SAGREIYA MEMORIAL LECTURE

What role can forests play in India's Intended Nationally Determined Contributions at the Paris Climate Summit

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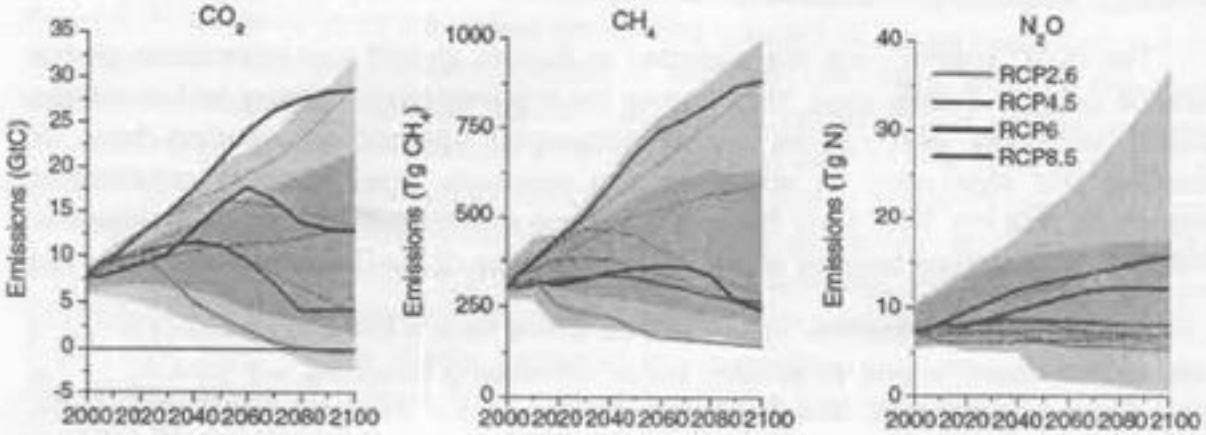
President and Members of the Society of Tropical Forestry Scientists; Director, SFRI, Jabalpur, Ladies and Gentlemen

I am indeed grateful to the Society of Tropical Forestry Scientists and State Forest Research Institute, Jabalpur, for according me the honor of giving this talk on "What role can forests play in India's Intended Nationally Determined Contributions at the Paris Climate Summit" in the memory of Mr. K P Sagreiya, one of the most eminent foresters that India has produced. Though Mr. Sagreiya had already retired when we entered the IFS in 1977, his was one of the first names we became familiar with because of the large body of work that he had left for us to learn from. Just a few weeks before we joined in March 1977, one of his famous paper "Making the Most of Forestry" had appeared in the Economic and Political Weekly which was then considered the epitome of intellectual achievement. Over a period of time, we became familiar with more of his works and it always left us wondering how he was able to write so many books and papers along with such a busy official life. He was one of those uncommon men gifted with both deep intellect and the willingness to harness it for a public cause.

As we all know, the Paris Climate Summit in December this year is slated to be one of the most important events of this year, perhaps even of the past ten years and more, where 195 countries of the world are going to negotiate the steps that the humanity must together take to keep the global warming limited within 2 ^{0}C above the pre-industrial levels of earth's average temperature. Not too long back there were many climate sceptics, backed often by GHG emitting countries and industries, who would question the very idea that our actions can ever affect the earth in such profound a manner as the climate change around the globe is. But relentless scientific work by tens of thousands of scientists around the world, and their highly effective coordination by the IPCC has now ensured that the world is finally convinced that climate change is happening; that its consequences would be horrendous unless appropriate steps are taken urgently, and that the cost of action now is within the reach of the global society provided there is willingness to share the costs and technologies by those who are both responsible for it and are capable, too.

The IPCC has helped build scenarios that represent the possible pathways that the climate change trajectory may take depending on the kind of action that the global society is able to take in the coming decades. These pathways represent possible

patterns of GHG emissions over time till the end of this century in response to growth in population, nature and pace of technological developments, changes in energy generation and usage, patterns of land use and land use change, global and regional economic circumstances, and willingness to share technologies and financial costs by the developed countries. These are called Representative Concentration Pathways RCP 8.5, RCP 6, RCP 4.5 and RCP 2.6 where the numbers indicate the radiative forcing in Watt/m^2 by the year 2100.



Slide 1: CO_2, CH_4& N_2O emission scenarios along the various RCPs

Representative concentration pathway	Radiative forcing	CO_{2eq}	Temperature anomaly
RCP 8.5	8.5 W/m^2 post 2100	1370 ppm	4.9 ^{0}C
RCP 6.0	6.0 W/m^2post 2100	850 ppm	3.0 ^{0}C
RCP 4.5	4.5 W/m^2 post 2100	650 ppm	2.4 ^{0}C
RCP 2.6	2.6 W/m^2 post 2100 after peaking at 3 W/m^2 mid century	490 ppm	1.5 ^{0}C

Slide 2: Temperature rise by year 2100 along different RCPs

At the recently concluded Lima Climate Summit, it was agreed that all countries of the world, both developed and developing, and the in-between, would make their best efforts to try to ensure that the world takes the RCP 2.6 and thus limit the increase in temperature to below 2^{0}C. In what has been appreciated as a bottom-up approach, all countries were asked to submit their Intended Nationally Determined Contributions (INDCs) representing their most ambitious, and fair, climate targets to the UNFCCC by

Oct 1, 2015 so that the global community could enter into negotiations at Paris in December 2015 with a better appreciation of what each country has to offer for meeting the climate challenge. These contributions are required to be beyond their current undertakings. And while the primary motivation behind INDCs was mitigation targets and financial and technological contributions towards it, the countries can also include an adaptation component in their INDCs and many countries, including India, are expected to accord central importance to adaptation.

The INDC submissions are expected to include quantifiable information on the reference point and base year, time frames for implementation, scope and coverage, planning processes, assumptions and methodological approaches including those for estimating and accounting for emissions and removals. They are also expected to demonstrate how the INDCs are fair and ambitious under their national circumstances, and how they contribute towards achieving the objective of the Convention.

It is not clear yet whether India's INDCs would have a forest component or not. It would be instructive to see what other major developing countries are thinking in this regard. For many countries, forests are an attractive option as higher levels of emission reduction in industrial production, agriculture and transport sectors could be disruptive to the economy and may lead to increase in unemployment, at least, in the initial stages. Indonesia is likely to propose a 41% decrease in its GHG emissions amounting to 1.189 $GtCO_{2e}$ out of which as much as 1.039 $GtCO_{2e}$, or a whopping 87%, would be contributed by forests and peat alone. In the case of Malaysia and Vietnam also, forests are expected to be a major component. Let us see what the possibilities in the Indian forests are.

Sector	GHG emission reduction
Forest and Peat	1.039 $GtCO_{2e}$
Waste	0.078 $GtCO_{2e}$
Energy and transport	0.056 $GtCO_{2e}$
Agriculture	0.011 $GtCO_{2e}$
Industry	0.005 $GtCO_{2e}$
Total	1.189 $GtCO_{2e}$

Slide 3: Indonesia's likely INDC at 41% emission reduction

We, in India, feel justly proud of the fact that we transited from gross loss of forest cover to gross gains in the early 1990s. Forest transition in an agricultural economy usually occurs when a degree of prosperity reaches large sections of the society accompanied by a shift towards industries and services and increasing demand for an improved physical environment leads to public policies favoring reforestation and

conservation. India is a rare exception where this transition began when the country was still steeped in deep poverty and heavily dependent on agriculture because of enactment of conservation oriented policies in 1970s originating in the vision of a great political leader rather than demand of the people.

Before we go further, let us see how forest transitions have occurred in various geographies across the globe. Loss of forests has always been a source of concern for thinkers in societies from the oldest times. The concept of 'forest transition' was first developed by Professor Alexander Mather of Aberdeen University, who has extensively studied the economic, political, social, ecological, religious and aesthetic reasons behind the changes in forest cover in his country and beyond. He discovered that the Scots had cleared most forests for agriculture by the end of sixteenth century but soon farmers realized that leaving lands of very low fertility altogether, and using their labor and other resources for more productive economic activities, would allow them both more income and increased leisure time. These leftover fields were then reoccupied by forests over time and as forests increased in the neighborhood, the lands in villages with larger extent of forests were valued higher as fuel was plentiful and hunting provided an occasional welcome meat, besides a number of other forest goods and services.

But it was not always economic development that brought forests back. Some of the earliest forest transitions that took place in France owe their origin to the plague which devastated the country repeatedly in the fourteenth and fifteenth centuries The first cycle of this dreaded epidemic that began in Italy in the autumn of 1347 and travelled clockwise through Europe till its end in the severe cold of Russia in 1353, brought death on a scale unknown till then. This was followed by many more cycles which decimated France's population by about a third and played a crucial role in the return of forests on the leftover agricultural fields. By the early part of seventeenth century, plagues receded in the face of resolute national response and the population increased again with increased losses of forest cover. The most recent forest transition in France that began around 1840s, however, followed the post industrialization rapid economic development.

Prof Mather also discovered that forest transition did not have much to do with good governance. He examined the forest transitions, or the lack of it, in Malaysia, Thailand, China, India and Vietnam and observed that while the first two are far ahead of the last three in government effectiveness, control over corruption and adherence to the rule of law, it was the last three that achieved transition. The deciding factor was perhaps the strong legal and policy backing to forest conservation and expansion in all these three countries which implies that, on balance, the political economy of these

countries favored forest expansion, something which clearly was not the case in Thailand and Malaysia.

Coming back to India again, this transition has come at a high human cost and vast contiguous tracts of forests in central and eastern India are today home to the poorest Indians and the kind of protection oriented forestry practiced on the forest lands that cover large parts of the affected districts has failed to create income and employment generating opportunities trapping the local people in perpetual poverty. These lands can neither be used for generating forest based economic activities on a large enough scale nor diverted for non-forestry economic activities. For some reasons, we appear to have convinced ourselves that natural forests are meant only for conservation of biodiversity, wildlife habitats, soil and water and of environment in general and that timber harvesting is incompatible with the scientific management of these forests. Restrictions on logging have become flags for the demonstration of our commitment to forests. The Supreme Court of India has tended to interpret the provisions of Forest Policy in favor of increasing restrictions on harvesting under the continually expanding umbrella of the Godavarman case leading to a situation under which often the only trees harvested across this vast country are those dead or severely diseased or illegally removed.

Forests as an economic resource have thus receded sharply in the background and create little employment and business opportunities. Full time equivalent employment in primary production of forestry goods and services in India declined from 6.36 million persons in 1990 to 6.19 million in 2005 while the employment in management of protected areas remained static at the insignificantly low figure of a mere 24600 over the entire country even as the population increased at quick pace.

It would require large scale investment of financial and human capital, and foundational changes in the way forests and forestry is viewed in the country, to bring significant impact on poverty reduction in the affected zone. The expected large investments in mitigation of climate change, and adaptation to it, as India prepares to move into the INDC program offers hopes of addressing the problem if fundamental changes to forest management policies could be made. Here, we propose the changes necessary and the likely outcome. An excellent FAO paper by Nair and Rutt estimates that an annual investment of $1 million in afforestation, reforestation and desertification control, improvement of productivity of existing planted forests, watershed improvement, indigenous forest management, forest conservation, agroforestry, fire management, disease and pest control, urban and peri-urban forestry, eco-tourism, skill improvement of forestry and wood industry workers with the objective of sustainable forest management would create full time equivalent annual jobs for 500 to 1000 people in

developing countries. And with almost the entire wages of the forest worker going into the local economy for procurement of the needed goods and services, every job created generates an additional 1.5 to 2.5 jobs in the economy.

For this to happen in India, it would involve a massive shift from the existing low investment forest management that merely focuses on keeping people away from harming forests, besides some attempts at joint management of peripheral forests with the neighborhood people, to intensive forest management that is dynamically adaptive to changing climate while maximizing the rate of carbon sequestration and enhancing economic returns from forests consistent with the requirements of biodiversity conservation and protection of wildlife habitats. This would mean keeping forests young and vigorous except in forests earmarked for conservation, increasing in situ and ex situ carbon storage, increasing substitution of fossil fuel intensive products with wood, enhanced use of modern forms of bioenergy, intensive forest fire prevention by segregation and by the timely removal of inflammable material on vulnerable forest floors, weed and pest management. It would also mean appropriate thinning which we seem to have forgotten altogether and some, who should know better, actively oppose even the thinning of infected Sal trees even when all evidence suggests removal of beetle infested trees is crucial to saving forests against. I recall that in the thinned forests of eastern Finland, the productivity is 4 m^3/ha/yr which is four times the productivity of un-thinned Russian forests just a little distance away. And there must be any number of similar examples in India.

In the model based on gross Indian forest inventory data in the Slide below, it is assumed that in temperate and tropical forests, an average of 30 and 20 years respectively would elapse for the diameter classes to move into the next higher class, that trees in the highest diameter class are available for harvesting, and that during the same period, the lowest diameter class will also get populated by fresh regeneration of the same measure as now through intensive regeneration practices. We further assume that ecological considerations preclude harvesting over 50% of mountainous temperate forests and 20% of tropical forests. This would mean harvesting of 100 million m^3 which, at an average price of US$ 150 per m^3, translates into annual revenues of $15billion. Let me add here that it is only a macro level model and not a harvest prescription by any means.

Type of forests	10-30 cm diameter		30-50 cm diameter		50+ cm diameter	
	Stems in millions	Vol in million m^3	Stems in millions	Vol in million m^3	Stems in millions	Vol in million m^3
Temperate	831.65	126.54	283.90	265.26	134.55	542.57
Tropical	10896.73	1524.63	1726.88	1612.71	536.33	2305.70

Slide 4: Estimated number of stems and volume by species and diameter class in temperate and tropical forests of India (Adapted from SFR 2009)

This level of ecologically sustainable harvesting would be possible only in very intensively managed forests. In the immediate time frame, this means large investments in activities that may include consolidation of forest boundaries through survey and maintenance of related land records, comprehensive asset inventorization, preparation of forest working plans, replanting cleared lands, intensive protection against fires, weeds and pests, harvesting timber and non-timber and initial value addition, decentralized biomass energy production for meeting local energy needs, ecotourism, and capacity building of suitable members of the local communities for all of the above and related activities. Forest certification covering all forests and tree assets that produce marketable forest goods is a critical part of sustainable management of forests and would need to be introduced across the country. Primary activities in conservation areas including significant wildlife habitats should be effective law enforcement against illegal tree felling and poaching of wildlife through intensive intelligence gathering and patrolling.

In soundly managed timber rich public forests, expenditures usually amount to about two third of the revenues generated. This implies an additional investment of $ 10 billion annually into the forests in addition to the current levels of expenditure and an employment generation of 7.5 million additional full time jobs assuming 750 jobs per million US$ of annual investment. Since under the forest management and ownership patterns obtaining in the country a significant part of these revenues would actually flow to the communities and would not usually be accessible for reinvestment the climate change financing provisions would be required for the purpose besides the central and state governments' own resources.

Annual addition of 100 million m^3 of commercial sized wood into the harvestable diameter class represents carbon sequestration during the year. Taking average values of biomass expansion factor of 2, root to shoot ratio of 0.27, wood density of 0.5, and

carbon factor of 0.5 this translates into a possible annual sequestration of 233 million tCO_2 compared to 138 million tCO_2 assessed presently, a very significant increase. In addition, assuming conversion of half of the annual harvest of 101 million m^3 into durable forestry goods of an average lifespan of 10 years means storage of about 50 million m^3 of timber or about 12.5 million tons of carbon (46 million tCO_2) away from the atmosphere for a period of 10 years. It would be reasonable to assume that the remaining half of the timber would find utilization as carbon neutral bioenergy (replacing fossil fuels) within a year since most of wood waste in India gets utilized for energy purposes.

The forests in India are predominantly tropical evergreen and tropical deciduous forests both of which have relatively high net primary productivity and nitrogen uptake and thus have good mitigation potential. The task of the management is to optimize the mitigation values without undue compromises on the other non-carbon values of the forests.

Forest type	Area (million km^2)	Mean NPP ($gmC/m^2/yr$)	Mean N_2 uptake ($gmN/m^2/yr$)
Tropical Evergreen	17.4	1098	25.1
Tropical deciduous	4.6	871	26.2
Temperate broadleaf	3.2	741	6.2
Temperate mixed	5.1	669	7.3
Temperate deciduous	3.5	620	7.6
Xeromorphic	6.8	481	11.7
Temperate coniferous	2.4	465	3.7
Boreal forest	12.2	238	2.5
Boreal woodlands	6.3	173	1.5
Wet tundra	4.7	120	0.8
Alpine tundra	5	87	0.7

Slide 5: Global ecosystem based assessment of net primary productivity {Source: Nature 363 (1993)}

Now turning to adaptation to climate change, which should attract larger investment with greater emphasis being given to adaptation in developing countries, the forest ecosystems are subject to two dynamic processes. One is its physiological growth and decay based on the response of individual species to the general physical and biological environment and the other caused by occasional but powerful events like

cyclones, lightning, droughts, fires and floods. The vulnerability of mountain forests is even higher due to the limited area of optimal climatic requirements of vegetation often aggravated further by habitat fragmentation.

The natural response to increase in vulnerability is to migrate to sites of lower vulnerability through seed mobility. This natural adaptation in forest species is observed in the Santa Rosa Mountains of California where the average elevation of the dominant plant species has moved 65 m upwards over past three decades and in the Mediterranean forests an upward shift of 29 m per decade in optimum elevation species has been noted. Attempts to project migration rates are being made using paleological evidence of the migration of tree species. A dispersing tree population would move out at a speed determined by its seed dispersal mechanism in semi-circular waves, with the bordering seeding trees as multiple centres. When their current locations become more stressed under the warming climate, the diffusing population would resemble a constant speed **Gaussian curve**, flattened at the centre where circumstances are yet to become favourable.

At this stage, it would be interesting to divert a little to an interesting phenomenon called the **Reid's Paradox** after the nineteenth century British paleo-botanist who observed that for some species with heavy seeds, such as oak, the observed pace of migration was actually far too rapid than that suggested by such a Gaussian surface that can only move at slow speeds with acorns too heavy to be moved by winds. There have been many attempts to explain this anomaly and, as a possible explanation, Reid had also written about the possibility of long-distance dispersal through birds beyond the Gaussian frontiers of seed movement. Extreme weather events like cyclones, increased in both frequency and severity due to rapid warming, could also have carried the seeds to the distant cooler locales and found environments favourable to their survival. And the fact that the birds and mammals would have also been migrating in the same direction to higher latitudes with retreating ice would have facilitated the dispersal to these farther sites. Once established, radiating seed dispersal from these outlying populations would have similarly colonized lands further afar.

In India, we need to undertake research in paleo-migrations which would be useful in modelling migration pathways of the future and also help plan harvesting at an increased rate to capture the value of wood before decay takes over. Shorter rotations could also facilitate adaptation. Modelling would also be helpful in giving us insight into the likely insect and pest infestation in our forests, the borer attack on Sal forests for example, as warming intensifies. In this, we could learn from the forest researchers in USA and Canada who have gained considerable knowledge from bark beetle infestations in Alaska and elsewhere in the continent. At least a million ha of pine and

spruce forests in southern Alaska have been damaged by the bark beetle as all environmental defences of the trees appear to have been dismantled by the warming climate. The beetle, with its shorter life cycle and high mobility, has obviously done a far better job at adapting to the warmer climate than its host trees.

As foresters it is our job to strengthen up the defences of the trees. The borer attack that has destroyed large patches of economically highly valuable *Shorea robusta* forests in central and northern India appears to be linked to climate change. Here adaptive action may involve chemical control of the beetle and quicker removal of the dying and the diseased trees that become easy hosts for the beetles. Shorter rotations would thus generally constitute an important aspect of future adaptation-guided management in these stressed forests. Properly managed adaptation processes can thus generate higher economic values to the present generation, compensating for the sacrifices they would be required to make and work to ease the pain of change. This would also make adaptation an economically attractive activity, easily the most effective means of attracting higher flow of funds towards adaptation.

Other key areas for adaptation action would be management of fire and weed and assisting natural regeneration. In the case of fires, we have established state of the art warning system but the response to fire warning is still of the nineteenth century vintage. The increased threat of fires under the warming climate requires multipronged responses by way of both preventive and curative action. Besides fire lines for physical separation of fire prone areas, we also need to invest in, where possible, reducing inflammable material from the forest floor and find appropriate use for the biomass removed. Curative responses must include aerial sprays to control dangerous fire occurrences.

On a rough guess, more than a third of the forest area of the country is heavily infested with weeds like lantana that have smothered all natural regeneration and reduced forest productivity. Resource crunch has prevented us from eradicating it from the forests as a comprehensive removal of these weeds is a costly exercise. Under the INDC financing systematic removal of the weeds and immediate replacement with ecologically appropriate and economically useful species should be possible in phases.

Assisted natural regeneration would require grazing management combined with gap planting and appropriate silvicultural management of forest openings. Grazing is often the single biggest cause of poor regeneration and attempt to impose rotational grazing by using closure notices published in district gazetteers rarely work in the present societal environment. Exclusion of grazing would require both finances, and social and technical skills in good measure.

So far I have discussed some of the more important mitigation and adaptation actions in forestry sectors that could be included in India's INDCs that would serve the global interest of climate mitigation as also our interests in making our forests ecologically strong and economically vibrant and contribute to significant rural employment generation in the country. A key requirement is that the INDCs proposed should be fair and ambitious. Fairness, that is, enhanced equity, is largely ensured because by the very nature of forestry practiced today in India, the community is a partner in decision making and the national and international oversight on the activities undertaken would take care of any shortcomings that might arise in this. The other test is whether the mitigation targets set are ambitious. In my view, the projected sequestration of 233 $MtCO_2$ as against the 138 $MtCO_2$ currently, annual storage of 48 $MtCO_2$in wood products and, in addition, significantly increased quantities of biomass available sustainably for energy is quite an ambitious target.

What is needed now is a robust debate on the subject among the forestry community so that a comprehensive view could be communicated to the government as soon as possible. I am sure today's event would contribute to this debate. I am thankful to the Society of Tropical Forestry Scientists for giving me this opportunity and to you all for so patiently listening to me.

Thank you very much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