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RESEARCH NOTE

(I)

Forests, Trees and Agroforestry: Their Roles in India's Sustainable Development and Climate Action

Forests, trees, and agroforestry have a key role to play in India's sustainable development and climate action. Here some scenario simulations are discussed for carbon mitigation potentials by 2050 from forests, trees, and agroforestry systems showing that major benefits could be obtained through sustainable land use practices nationwide. However, lack of data availability and sometimes lack of data sharing mechanisms can adversely affect research in these areas. There is an increasing need for innovative forestry informatics tools and integrated databases towards a more effective climate action.

The recent coronavirus outbreak has spotlighted the consequences of unsustainable development pathways on our health and well-being, including environmental degradation and biodiversity loss (Platto *et al*., 2020 and 2021). One hopes this bitter experience makes humanity wiser to address other environmental issues on priority. Climate Change is another environmental concern that has already started to unfold and adversely impact vulnerable populations, including forest dependent communities in India and other developing geographies.

Global mean surface temperatures have already risen by more than 1°C since the pre-industrial times (Met Office, 2015). This apparently small increase has already impacted our natural production systems, from heat waves to unseasonal rains. Impacts of observed climate change on forest ecosystems have been particularly devastating, especially in the form of forest fires, as witnessed in Australia, Brazil, Canada and the United States in the recent years (Abram *et al*., 2021). India thankfully has not been seriously impacted from wildfires on its forest resources yet. A global mean temperature increase of 2°C or even 1.5°C is considered the dangerous threshold, beyond which it is understood that the ability of natural ecosystems to provide critical ecosystem services will be gradually compromised (IPCC, 2018). For example, it is projected in some scenarios that a 2°C warming alongside continuous forest degradation, especially through land use change and wildfires, would cause a “savannization” process in several parts of the Amazon rainforest (Sales *et al*., 2020).

To reverse these alarming trends, a moment of international hope came in the form of adoption of the Paris Agreement in 2015, when 196 countries pledged to limit warming to 2°C, while also pursuing the goal to limit the warming to 1.5°C until the end of this century. Aiming to restrict warming to these targets, the Paris Agreement required its signatory parties to voluntarily pledge emission reductions through Nationally Determined Contributions (NDCs) until 2030, while also requiring global emissions to achieve carbon neutrality by mid-century (UNFCCC, 2015a). A total of 196 countries pledged emission reductions in their NDCs, including India, as well as the departure and rejoining of the United States to the agreement. Nonetheless, a recent analysis suggested that all NDCs and long-term commitments (pledges) taken together are insufficient to meet the Paris Agreement goals, as current emission pledges are projected to increase global mean surface temperatures by 2.4°C by 2100, compared to the pre-industrial base (CAT, 2022). While near term global commitments as part of the Paris Agreement remain insufficient (UNFCCC, 2015b), our actual actions on the ground in the interim years since the Paris Agreement remain even more fragmented. In 2019, for example, despite all the awareness and pledges, global greenhouse gas emissions hit a record high, though 2020 saw a dip due to the covid pandemic (Le Quere *et al*., 2020). While near term pledges remain insufficient and ground actions in the last decade remain unsatisfactory, global focus is increasingly shifting to long-term commitments of carbon neutrality in 2050s and beyond. However, lofty long-term pledges in absence of matching short-term actions may not be very helpful for our planet's sustainability.

In an international context, including country size, gross domestic product, and population, India's actual emissions remain relatively low at 2.5 $GtCO_2$ in the year 2015, when compared, for example, to China's 11.5 $GtCO_2$, which has a comparative population, (MoEFCC, 2021; Shan *et al*., 2018). According to Climate Action Tracker (CAT, 2022), India's policy and action on climate change, pledged by 2030 with a net zero target by 2070, is rated as 'almost sufficient’ for a 2°C compatible pathway, although still ‘insufficient’ for a 1.5°C trajectory. The CAT is a consortium of global institutions working on climate change issues. While, India's near-term climate pledges and actions are commendable, India should also plan for 2050 and beyond more strongly, as to how

India could best help the global community in cutting emissions, while also ensuring increased income for its farmers, employment generation and poverty alleviation for its 1.33 billion population.

Keeping this question in mind, our research teams from IIM Ahmedabad, BITS Pilani and partners worked together to project India's emissions under different scenarios until 2050. We here share some insights from the preliminary results of this study, which is particularly focussed on the sink capacity from the land use change and forestry sector in India.

In the first scenario we assume the current policies to be continued (Current policy scenario) from 2015 to 2050. India's current forest and tree cover area comprises a little less than one fourth (25%) of its total territory. Despite its high population and livestock density, India has been successful in keeping deforestation at bay. However, its high population density means that there is a limit to increasing its forest area for climate change mitigation and sustainable development. Therefore, in the current policy scenario it is assumed that forest area in India increases only modestly from 70 Mha in 2015 to 78 Mha in 2050 (slightly higher than over the historical trend). Besides, increasing forest density represents an opportunity for additional carbon sequestration. It is estimated that, under the current policy scenario, increasing forest area and increasing forest density together leads to a sequestration of about 160 $MtCO_2$ per year in 2050.

The second scenario, termed as “Development First” scenario, is built around India's key developmental ambitions of AtmaNirbhar Bharat (self-reliance), doubling of farmer's income and building climate resilience in agricultural communities via diversification of farm incomes (NITI Ayog, 2018). Due to stringent forestry protection laws, India currently imports about 20 million cubic meter (MCUM) of timber from New Zealand, Malaysia, African countries, Latin America, US, Canada and EU (CSE, 2019), costing it about USD 8-10 billion in 2019 (NCCF, 2017). These imports are often unsustainable due to deforestation in some exporting countries and the large carbon footprint associated with maritime freight. Currently, much of domestic legal timber production (94%) comes from trees outside natural forestlands, such as agroforestry systems, whereas only 6% of the legal domestic timber is obtained via auctions of wood from natural forests (CSE, 2019). Currently, about 10 Mha of area is under agro-forestry in India. It is estimated that as the agro-forestry area rises to 25 Mha in 2050, it may be able to satisfy India's projected wood demand in 2050 (260 MCUM as against wood demand of 152 MCUM in 2020), creating additional income opportunities for Indian farmers. This additional income could not only significantly boost farmer's income, but also diversify their income and provide a hedge against increasing agricultural losses from unseasonal rains, extreme rainfall events and other weather-related extremes. This will go a long way in creating resilience in distressed agrarian communities. Moreover, agroforestry has strong synergies with forest conservation (halting forest degradation and deforestation) as a recent CSE report (CSE, 2019) concluded that “a tree grown outside forest is a tree protected inside forest”. It is estimated that, under the 'Development First scenario', the addition of agroforestry may lead to a sequestration of about 134 $MtCO_2$ per year in 2050.

Besides agroforestry, the 'Development First' scenario also emphasizes enhancement of soil organic carbon (SOC) in croplands. It is estimated that as conventional cropland is converted into no tillage systems it sequesters a substantial amount of soil carbon due to the incorporation of organic matter, while also increasing nutrient recycling and at the same time reducing soil erosion. Expansion of agroforestry on additional 15 Mha naturally results in an annual soil carbon uptake of about 15 $MtCO_2$ by 2050. In addition to the agroforestry potential, Indian cropland soils are generally found to be low in carbon content. Low carbon content means low soil fertility which results in low food grain production. Multiple studies have pointed out that in order to achieve food security and higher grain yields, India needs to increase SOC content in its agricultural soils. An assessment by Lal (2004) suggests that it is feasible to sequester about 50-60 $MtCO_2$ in Indian cropland soils per year by 2050 nationwide through a number of interventions, including no tillage agriculture, agroforestry, manuring and other sustainable management practices, as opposed to the current sequestration of about 5-8 $MtCO_2$ per year while increasing crop yields and farmer's income simultaneously.

Therefore, forests, trees, and agroforestry, along with sustainable crop management, can provide major benefits for carbon mitigation in India. However, land use change and forestry sector-based estimates are characterised by significant uncertainties (IPCC, 2006). Especially lacking are time-series datasets around species wise inventory of forest and tree species at a finely gridded level for sub-regional administrative boundaries. Area estimates for agroforestry practices vary a great deal. Reliable soil carbon change estimates at national level are scarce and the local and regional scale data is too fragmented across many sources. Lack of data availability, data authenticity and sometimes lack of data sharing mechanisms adversely affect research in these areas. Therefore, given the urgency of India in achieving its climate change goals and the large potential for carbon mitigation via forestry, agroforestry and other land use strategies, it is imperative to have

innovative forestry informatics systems and data sharing schemes to help address and monitor future advancements in these areas more accurately.

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RAJIV KUMAR CHATURVEDI, ALEXANDRE STRAPPASON[1,2] AND AMIT GARG[3]
K K Birla Goa Campus, BIT Pilani, Goa-403726
Email: Chaturvedi.rajiv@gmail.com

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[1]BelferCenter for Science and International Affairs, Harvard University, Cambridge, MA 02138, United States.
[2]Centre for Environmental Policy, Imperial College London, London SW7 1NE, United Kingdom.
[3]Indian Institute of Management, Ahmedabad, Vastrapur, Ahmedabad- 380015