OPINION

India faces a long and winding path to green climate solutions

Reinmar Seidler[a,1] and Kamaljit S. Bawa[a,b,1]

A little over a year ago, the global community proposed an ambitious new set of Sustainable Development Goals (SDGs) to protect the environment and enhance human well-being. Three months later, the United Nations Conference on Climate Change, CoP21 in Paris, announced equally ambitious new targets for action on climate change. Such bold commitments have been facilitated by development trends in several emerging economies. India, for one, has made truly astonishing gains: the World Bank reports that in over just seven years, from 2004 to 2011, the number of Indian citizens living in acute poverty fell from 426 million to 263 million, a reduction in the proportion of the population in poverty from 38% to <22% (povertydata.worldbank.org/poverty/country/IND; iresearch.worldbank.org/PovcalNet/index.htm).

At the same time, however, industrialization has reduced India's natural forests, dried up rivers and aquifers, eroded ecosystem services and biodiversity, extracted a heavy toll on public health, and exacerbated social and economic inequities. As millions more are lifted out of poverty, per capita energy consumption in India—currently just a third of the global average—is expected to double by 2040. India may soon overtake China as the primary global locus of growth in energy demand (1).

Thus, India joins the United States, Europe, and China as a major player in global efforts to mount a

In order to meet its stated carbon reduction goals, India will need to rapidly increase forest cover in many regions. Pictured here: Lachung Valley, Sikkim in northeastern India.

[a]Department of Biology, University of Massachusetts, Boston, MA 02125; and [b]Ashoka Trust for Research in Ecology and the Environment, Bangalore 560 064, India

Author contributions: R.S. and K.S.B. wrote the paper.

The authors declare no conflict of interest.

[1]To whom correspondence may be addressed. Email: reinmar.seidler@gmail.com or kamal.bawa@gmail.com.

coherent climate response. Implementation of the Paris Agreements depends crucially on India's continued cooperation in meeting its Intended Nationally Determined Contribution (INDC) commitments. However, India's stated plans to implement its INDC while pursuing parallel SDGs fail to add up, largely because planned carbon sink expansions cannot compensate for increased aggregate emissions. As the global community moves enthusiastically toward ratification of the Paris Agreements, possibly even this year, INDCs must be subject to appropriate critical scrutiny.

India's current and anticipated rates of energy production and consumption demand a reevaluation of its proposals in light of the policy instruments, institutions, and governance needed to reconcile INDC and SDG goals through green economic growth. To achieve this difficult balancing act, India will need to rethink its reforestation targets and processes, rapidly build out its strengths in satellite technologies, and reorganize several government initiatives to avert delays, conflicts, and redundancies.

Mitigation Plans

The current Indian administration firmly believes increased public access to commercial energy is essential for achieving the SDG goals. To accommodate exploding demand for electricity, India's INDC projects a fivefold increase in production from renewables, from a total of 36 gigawatts in 2015 to 175 gigawatts in 2022. However, the aggregate energy mix is still expected to come mostly from coal; in that sense, India is defying the global trend of declining coal use. The country's domestic coal production targets for 2020 are more than twice those of 2015, and by 2040 nearly half the entire world's new coal-fired plant capacity will be built in India (2). Consumption will therefore continue to outpace production, greatly stimulating global coal markets because India will need to import increasing amounts of coal. Between 2004 and 2013, Indian coal imports ballooned from 12 million tons (Mt) to 142 Mt; India has now passed Japan as the world's second-largest coal importer.

Carbon dioxide sequestration estimates are fraught with uncertainties. What is certain, however, is that Indian forests experience the world's highest rates of fuel wood and fodder extraction, and this may reduce carbon stocks without directly affecting forest cover indicators.

This emphasis on coal for power means that by 2030, India's total CO_2 emissions could double or even triple to over 6 billion metric tons (3). In 2009, India committed to lowering carbon intensity (CO_2 emissions per unit gross domestic product) 20–25% below 2005 levels by 2020, by doubling wind capacity and increasing solar 25-fold. The 2015 INDC commits to further lowering the carbon intensity target to 33–35% below 2005 levels by 2030.

To achieve the promised net greenhouse gas (GHG) emissions reductions, India's INDC relies on ambitious projections of forest cover increases that would enhance carbon sequestration by about 10 Mt CO_2e each year through 2030. As part of the "National Mission for a Green India," the government anticipates regenerating five million hectares of new forest cover while improving the quality of an equal area of extant forest. By 2030, total net carbon stocks would increase by 2.5–3 gigatons CO_2e (or 166–200 MtC/yr). Carbon sequestration would thus account for over half the total INDC commitment to net emissions reductions; the rest is unspecified. But are these reasonable goals? There are clear indications that they are not.

Greening India?

According to Forest Survey of India (FSI) figures, the country's forest cover increased from 64 million hectares to 79 million hectares from 1999 to 2015, while forest carbon stocks increased by 103 MtC over two years: 2013–2015. However, FSI figures include single-species tree farms, fruit orchards, and coffee plantations in the "forest" category (4). These land uses differ widely from native forest in their carbon stocking rates and percentage canopy cover, as well as in their biodiversity values and secondary community uses. Independent estimates that discriminate between native forest and plantations show losses of native forest area ranging from 1.5–2.7% per year since the early 1990s (5).

Carbon dioxide sequestration estimates are fraught with uncertainties. What is certain, however, is that Indian forests experience the world's highest rates of fuel wood and fodder extraction, and this may reduce carbon stocks without directly affecting forest cover indicators. During the mid-2000s, such biomass extraction averaged 150 MtC/yr, at least three times the amount being added through new forest cover. Hence Indian forests may not be functioning as net carbon sinks at all (6). Even at FSI's high estimated sequestration rate of 50 tC/ha/yr, India would need to establish three to four million hectare per year of healthy new forests, while preventing further degradation of existing forests. Accepting the most optimistic figures claimed by FSI, this is three to four times the current annual increase in forest area. Are institutional resources available to guide such a rapid acceleration in afforestation? The country is only part-way there.

Institutional Landscape

India has developed progressive policy instruments that, with improvements in governance, can in principle help the country meet the targets set by the INDC and SDGs. Available institutional resources fall into two basic categories: (*i*) institutions intended to help constrain GHG emissions, and (*ii*) mechanisms for helping increase the country's carbon sequestration capacity. In principle, some kind of balance must be struck between emissions and CO_2 storage capacity. (However, there's an important caveat: India clearly intends to move in the direction of global parity in per capita energy consumption, so emissions will continue to rise rapidly in absolute terms.)

Legislation, including the Energy Conservation Act, the National Electricity Policy, and an Integrated Energy Policy focus on approaching universal public access to electricity while promoting renewables. Power losses from the grid are currently extremely high at an average of 25% (over 50% in some states), offering much scope for efficiency gains apart from new production. The

National Policy for Farmers focuses on sustainable development of the agricultural sector, another major source of emissions. Such programs, however, refrain from committing to specific GHG mitigation goals.

India's National Action Plan on Climate Change (NAPCC), guided by the Prime Minister's Council on Climate Change, is to be implemented by 12 missions scattered across several ministries and departments. The main initiatives to increase forest carbon sequestration are the Mission for Green India and the Mission for Sustaining Himalayan Ecosystems. Each of the 36 union states and territories has also submitted its state-level Action Plan, but these have been assessed as vague and unintegrated into development planning, and there has been little action over five years (7). CAMPA, the agency for "compensatory afforestation," collects money from mining and other industries in return for permission to convert public forests to private use. Over seven years, CAMPA has collected a huge reserve of US$ 5.83 billion. How this money should be spent is currently the subject of intense debate.

There has also been much discussion about the possibility of establishing contracts for REDD+ (an outgrowth of the United Nations program "Reducing Emissions from Deforestation and Forest Degradation"). But instead of integrating with other climate-related agencies, the India REDD+ framework sets up several new administrative units housed in the Ministry of Environment, Forestry, and Climate Change (MoEFCC), which is already struggling to accommodate the NAPCC system. Last year, only six full-time staff were deputed to climate planning in the MoEFCC (8), so there is a desperate need for more human resources focused on climate issues. Underfunding contributes to challenges in interagency communication and policy integration. A "muddling through" approach will not suffice to fully implement either the NAPCC or INDC (9).

Carbon Sequestration Challenges

Plans to sequester carbon through afforestation and restoration suffer from three central problems. First, as in other countries, Indian forests are contested domains, with government agencies and communities (including indigenous tribes) vying for management authority and usufruct rights. For example, a new bill (CAF 2015) proposes to devolve CAMPA money to states to fund afforestation efforts partly in collaboration with the private sector (10). Environmentalists fear that a sudden infusion of money into afforestation programs could overwhelm more nuanced goals of biodiversity maintenance and local community use in favor of new agency targets based on sheer acreage. In the past, this has often led to nonnative monoculture plantations replacing the mixed-species forests that are useful for fuel wood, fodder, for their fruits, as well as other household uses.

Second, because large-scale plans for coal mining focus on the same east-central states that have extensive forest area (and many forest-dependent communities), coal development and forests are on a collision course. Indian coal is shallow—no more than 300 meters below the surface—so it can only be extracted through open-cast mining. This is the form of mining most destructive to forests and to communities. Hydropower, too, though in principle associated with reduced emissions, has often proved inimical to forests. The Comptroller and Auditor General of India reported in 2013 on the "abject failure" of public and private hydro projects in the Himalayan region to carry out agreed compensatory afforestation projects. Globally, GHG emissions from reservoirs are consistently larger than anticipated (11), as are social and financial costs (12). Third, because of the first two problems, no government agency has yet been able to identify appropriate areas for large-scale forest restoration.

A Way Forward

How can India hope to meet its INDC targets? Here, we present a short-list of actions that would help.

First, leveraging technological strengths will be key. India is a powerhouse for development of satellite-based monitoring systems and geospatial technologies. These should be fully deployed to help the Indian Forest Service monitor forest cover realistically, along with a thorough assessment of land and resource rights to identify areas for restoration. The Green Accounting of Indian States Project provides a framework for comprehensive monitoring of green assets (www.gistindia.org/index.php?a=projects&b=gist_monographs). Such monitoring, combined with Indian Long Term Ecological Observatories and systematic ground-truthing of Missions progress toward INDC targets, is required to realistically assess spatial/temporal trends in green assets.

In India's case, the needs are clear: redoubled efforts in forest restoration and management—in addition to energy efficiencies, renewable energy systems, and climate-smart agriculture—that counterbalance rapidly increasing emissions from fossil fuel-based power generation.

Second, meeting the INDC carbon uptake goals will require revolutionizing India's afforestation policies and techniques, and forest management in general. There are currently no rigorous guidelines regarding habitat restoration or land reclamation projects. Land reclamation after mining, for example, remains haphazard in India (13).

Third, on the social front, the country has a record of progressive land rights legislation and decentralized governance systems for managing common-property resources, such as forests, but implementation has lagged behind. The CAF 2015 bill should consider the claims of local village bodies to participate in funding and decision-making, rather than privileging the private sector in establishing plantations.

Fourth, true convergence among climate-related policies is essential, and is an aim highlighted in many Indian administrative documents of the last 10 years. Convergence implies alignment of goals, sharing of information, even collaboration in implementation. However, these aspirations remain pie-in-the-sky as long as organizational structures foster competitiveness and detachment, rather than participation and interdependence. One symptom of this institutional separation is that after more than four years of existence, the Green India Mission recently published guidelines for states to report

progress on Mission goals. In fact, some of the states had already submitted their reports by the time the formatting guidelines came out; those states now have to redo their reports to meet the new guidelines. Thus, true convergence will require significant administrative realignments.

Fifth, we need more data from the field. South Asia is a complex geo-meteorological environment lacking in systematic climate science. The South Asian monsoon, so central to understanding Asian climates at any scale, remains poorly understood, although the threat of climate change is spurring systematic study of the monsoon and related systems (14). The variety of ecosystems across the subcontinent is largely caused by variations in the impact of the monsoon, but ecosystems have also been subject to intense anthropogenic manipulations over many human generations. A thorough understanding of the carbon sequestration rates of many forest types remains a distant goal, especially rates of carbon uptake in soils and below-ground systems. A major push is urgently needed to understand these parameters to model carbon uptake rates at administratively useful scales, and to link national-scale with global models (15). Progress on these fronts will require new investment in human and institutional resources capable of generating integrated knowledge. International investment, through mechanisms such as the Green Climate Fund, will also need to step up at a level not yet seen (16).

The need to respond to climate change is challenging every large nation to develop new and adequate administrative structures. India, of course, is not alone, as the United States, China, and others will have their own daunting challenges in fulfilling their INDCs (17–19). In India's case, the needs are clear: redoubled efforts in forest restoration and management—in addition to energy efficiencies, renewable energy systems, and climate-smart agriculture—that counterbalance rapidly increasing emissions from fossil fuel-based power generation. Resource governance should be conferred to local administrative bodies to facilitate flexible responses to changing conditions. Meeting or approaching the SDGs while fulfilling climate mitigation commitments will require closer administrative coordination and a more nuanced approach to growth to ensure that development and environment goals remain complementary.

India formally ratified the Paris Agreement on October 2, 2016, Mahatma Gandhi's birthday. The symbolic gesture alludes to Gandhi's thinking, which integrated ethics, economics, and resource conservation. All of these factors will come into play. Given India's strengths in science and technology, public policy, and civil society, the country has the potential to forge a greener development path over the next decades. And importantly, genuine progress toward realizing India's INDC aims would not only help with global emissions targets, but also provide a model for other countries facing similar formidable climate challenges.

Acknowledgments

This work was supported in part by grants from USAID India (AID-386 A-14-00011) and from the Barr Foundation (Boston).

1 OECD/International Energy Agency (2015) *India Energy Outlook: World Energy Outlook Special Report*. Available at www.worldenergyoutlook.org/india. Accessed August 25, 2016.
2 US International Energy Agency (2015) *India's Coal Industry in flux as Government Sets Ambitious Coal Production Targets*. Available at https://www.eia.gov/todayinenergy/detail.cfm?id=22652. Accessed August 25, 2016.
3 Commonwealth of Australia, Office of the Chief Economist (2015) *Coal in India*. Available at www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/Coal-in-India.pdf. Accessed August 25, 2016.
4 Ravindranath NH, et al. (2014) Forest area estimation and reporting: Implications for conservation, management and REDD. *Curr Sci* 106(9):1201–1206.
5 Puyravaud JP, Davidar P, Laurance WF (2010) Cryptic destruction of India's native forests. *Conserv Lett* 3(6):390–394.
6 Davidar P, et al. (2010) Assessing the extent and causes of forest degradation in India: Where do we stand? *Biol Conserv* 143(12): 2937–2944.
7 Gogoi, E; Oxford Policy Management (2015) *India's State Action Plans on Climate Change: Towards Meaningful Action*. Briefing note. Available at www.opml.co.uk/sites/default/files/india_state_action_plans_climate_change.pdf. Accessed August 25, 2016.
8 Dubash NK, Joseph NB (2015) *Building Institutions for Climate Policy in India. Policy Brief* (Center for Policy Research, New Delhi).
9 Morgan MG (2016) Opinion: Climate policy needs more than muddling. *Proc Natl Acad Sci USA* 113(9):2322–2324.
10 Bhushan C, Saxena AK (2016) *Fumbling with Forests: Why We Should Not Handover Forests to the Private Sector* (Centre for Science and Environment, New Delhi).
11 Li S, Zhang Q (2014) Carbon emission from global hydroelectric reservoirs revisited. *Environ Sci Pollut Res Int* 21(23):13636–13641.
12 Ansar A, Flyvbjerg B, Budzier A, Lunn D (2014) Should we build more large dams? The actual costs of hydropower megaproject development. *Energy Policy* 69:43–56.
13 Ravi R, Priyadarsanan DR (2015) Needs for policy on landscape restoration in India. *Curr Sci* 108(7):1208–1209.
14 Singh D, Tsiang M, Rajaratnam B, Diffenbaugh NS (2014) Observed changes in extreme wet and dry spells during the South Asian summer monsoon season. *Nat Clim Chang* 4(6):456–461.
15 Boucher O, et al. (2016) Opinion: In the wake of Paris Agreement, scientists must embrace new directions for climate change research. *Proc Natl Acad Sci USA* 113(27):7287–7290.
16 Lohani BN, Kawai M, Anbumozhi V, eds (2016) *Managing the Transition to a Low-Carbon Economy: Perspectives, Policies, and Practices from Asia* (Brookings Institution Press, Washington, DC).
17 Narain S, Bhushan Capitan America C (2015) *US Climate Goals, A Reckoning* (CSE, New Delhi).
18 Adve N, Kothari A (2015) A flawed climate road map. *Econ Polit Wkly* 1(42):14–17.
19 Greenblatt JB, Wei M (September 26, 2016) Assessment of the climate commitments and additional mitigation policies of the United States. *Nat Clim Change*, 10.1038/nclimate3125.