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Forest landscapes restoration measures as a cost effective solution for climate change mitigation and adaptation in India

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Abstract

Global deforestation and forest degradation have led to massive loss of biodiversity. Hence, it is important not only to protect but also restore the forest ecosystems. Forest biodiversity protection, biomass production and climate change mitigation and adaptation are important key motivation for forest restoration.

Tree-based landscape restoration is a widely accepted cost-effective measure to combat climate change. India's commitment of Nationally Determined Contribution to the Paris Agreement is to sequester additional 2.5 to 3 billion tons CO_2 equivalent by 2030 through increased forest and tree cover and this ties in with the Bonn Challenge commitment to restore 21 mha of deforested and degraded lands by 2030 (now increased to 26 mha during UNCCD COP 14 meeting held in Sept. 2019) as well as the SDGs. This commitment can only be met if existing forests are protected and improved and tree cover is extended by 25 to 30 mha.

The main objectives of the Forest Landscape Restoration (FLR) in India is to reverse the process of degradation of forests & improve its productive potential, improve the regeneration of native flora & enrich the biodiversity, and enhance biomass production, carbon stocks & incomes of the rural households.

For a successful FLR works in India, focus needs to be on proactive involvement of communities and local people, better coordination among the various government agencies and departments for effective implementation of project activities, robust Institutional mechanism, and continuous fund flow and support to sustain the activities and keep the restored areas intact.

Here, we present how India can achieve the NDC and Bonn Challenge through forest landscape restoration. Potential to increase forest and tree cover and the carbon sequestration that can be achieved has been discussed. This will support planning for landscape restoration through the past and on-going initiatives which identifies different types of interventions implemented..

Keywords: Deforestation and forest degradation; Climate change; Biodiversity conservation; Research; Landscape management

Introduction, scope and main objectives

Forest degradation is commonly defined as the reduction of the capacity of a forest to provide goods and services (FAO 2002). Forest degradation involves a change process that negatively affects the characteristics of a forest, and reduces the value and production of its goods and services, and is caused by disturbance which varies in origin, extent, severity, quality and frequency. Disturbance may be natural, human-induced or a combination of the two. Human-induced disturbance may be direct, such as that caused by logging or grazing, or it may be indirect, like the one caused by the spread of an invasive alien species (FAO 2009).

Forest degradation is a serious environmental, social and economic problem, particularly in developing countries. There are about 300 million people in the tropics, consisting of indigenous peoples, local

communities, settlers and smallholders, who depend on degraded forests and forest lands for their livelihoods, and they are often suffering from extreme poverty (ITTO 2002).

The global deforestation and forest degradation rates remain alarmingly high (FAO 2010). Potapov et al. (2008) estimated that only 22% of the world's old growth original forest cover remains intact. The global forest land base (which covers 30% of the world's total land area) is shrinking at a rate of 13 million hectares per year, mainly because of land-use change in the Tropics and Oceania (FAO 2010). Hence, it is of utmost importance not only to conserve but also to restore forest ecosystems (Roberts et al. 2009; Lambin and Meyfroidt 2011). This has generated increasing interest worldwide in the science and practice of forest restoration.

Forest landscape restoration (FLR) is increasingly important in management of natural resources. Ecosystem restoration, the process of assisting the recovery of a degraded, damaged, or destroyed ecosystem, may be perceived as a novel forest management objective (SER 2004). This paper presents a brief about the forest landscape restoration, some approaches and considerations about the restoration process, lesson learnt from the past FLR activities and FLR opportunities in India.

Forest landscape restoration (FLR)

Over the last several centuries, huge forest areas have been cleared since agriculture has spread and human populations have grown. About 30 percent of global forest cover has been completely cleared and a further 20 percent has been degraded (Minnemeyer et al. 2011). More than two billion hectares of degraded forest land worldwide offer potential for restoration & rehabilitation (Chaturvedi et al 2018), and provides a vast opportunity to reduce poverty, improve food security, reduce climate change, and conserve biodiversity.

Forests have a major role in the global carbon cycle and in climate change since they store a large amount of carbon in vegetation and soils (Ciccarese et al. 2005; Pan et al. 2011). An accepted definition of forest restoration is ''to re-establish the presumed structure, productivity and species diversity of the forest originally present at a site. The ecological processes and functions of the restored forest will closely match those of the original forest'' (Gilmour et al. 2000). Restoration attempts to return an ecosystem to its historic trajectory. Wherever forest restoration intervention is implemented on degraded and fragmented landscape, new forest emerging will not match the original old-growth forest in species composition (Fagan et al. 2008).

Forested landscape restoration goes beyond afforestation, reforestation, and ecological restoration to improve both human livelihoods and ecological integrity. Forest landscape restoration is an active process that brings people together to identify, negotiate, and implement practices that restore an agreed balance of the ecological, social, and economic benefits of forests and trees within a broader pattern of land-uses (Minnemeyer et al. 2011). Implementing FLR is challenging because of the need to consider political, economic, social, as well as biophysical context, in balancing competing interests and differing priorities for livelihoods versus biodiversity (Maron et al. 2012).

Priority areas for forest landscape restoration for biodiversity purposes are the reclamation and rehabilitation of habitats of key species, isolated islands, in degraded areas within protected areas or in the buffer zones, corridors between intact fragments, riparian areas, or firebreaks around protected areas. Restoration planting can also be a compensation to remedy or mitigate the adverse impacts of development schemes and projects (Ciccarese et al. 2012).

UN General Assembly has declared 2021-2030 the UN Decade on Ecosystem Restoration. A UN Decade on Ecosystem Restoration offers the opportunity to multiply grassroots campaigns and to spur action from governments, private companies and investors. This will give a big boost to global efforts to restore the world's forests and other ecosystems like 2011-launched Bonn Challenge. Restoration of deforested lands is a global priority spurred by ambitious international commitments (Menz et al. 2013). For example, global initiatives, such as the Bonn Challenge and the New York Declaration on Forests (Conway et al. 2015), aim at restoring

350 million ha of forests on degraded forest and deforested land by 2030. Worldwide, 58 countries, states and companies have pledged to restore 160 million hectares of deforested or degraded land as part of Bonn Challenge. Regional initiatives, such as 20×20 and AFR100, aim to restore 20 million and 100 million ha, respectively in Latin America and Africa. Within these initiatives, activities involving tree planting and soil preparation could cost between US $1,400/ha and US $34,000/ha (Catterall 2006; FAO/RECOFTC 2016), an enormous barrier for scaling up forest restoration worldwide. Restoration costs vary widely according to the different methods applied, ranging from lower-cost approaches for natural regeneration to higher-cost approaches for active restoration (Chazdon 2008; Birch et al. 2010; Holl and Aide 2011).

There are three major objectives to restoring forest: (1) to produce forest products (timber and other products) or spaces for recreation, (2) to produce regulatory ecosystem services and (3) to achieve improvement of rural livelihoods. The large international programs and projects promote forest restoration for biodiversity conservation, regulatory ecosystem services and improving wellbeing of resident populations. Some of the findings related to the development of the forest restoration frontier suggest that some of the ambitious goals may be unrealistic and result in unwanted outcomes (de Jong et al. 2021).

The UN estimates that meeting the restoration goals of the Bonn Challenge could generate ecosystem services worth US$9 trillion, as well as improve the livelihoods of millions of people and help reverse the loss of biodiversity. It would also absorb 13-26 gigatonnes of carbon dioxide. Restoring forests is a critical part of every scenario mapped out by the IPCC that gives a chance of keeping global warming below 1.5°C. Several methodologies have been designed to help countries or regions analyze possibilities for forest landscape restoration. The restoration Opportunities Assessment Methodology (ROAM) helps national planners identify priority areas for restoration within their territories.

Some considerations and approaches to FLR activities

Plantation forestry remains the most effective approach for restoring large areas of forest cover and producing wood for energy and the industry. Planted forests account for about 7% of global forest area or about 2% of global land area, covering around 264 million hectares per year, with a steady increase in all regions since 1990. They supply 40% of the total global commercial wood requirements and their productivity is also increasing (FAO 2010). Indeed, intensive practices have increased plantation forest productivity by up to six-fold over the past 40 years relative to unmanaged, naturally regenerated stands (Vance 2010).

Depending on the objectives of the forest landscape restoration project, there are a number of strategic factors that needs to be considered viz., site preparation, land contouring, fertilization, choice of species, plant establishment, early maintenance, and management procedures. A key factor for successful forest restoration project is matching planting stock type and quality to requirements (Ciccarese et al. 2012).

The biological, physiological and genetic quality of forest planting stock needs to be improved. The low standards of forest nursery technology have contributed to a situation where improvements in seed quality and the possibilities to produce forest planting stock through cuttings or tissue culture have not been much utilized in practice. To effectively support forest restoration, nursery technology for producing forest planting stock needs to be improved within important areas such as mass production methods, genetic gains and reducing environmental impact. Plant biotechnology may be a strong tool for supporting forest restoration.

Natural forest regeneration is the spontaneous recovery of native tree species that colonize and establish in abandoned fields or natural disturbances (Shono et al. 2007; Zahawi et al. 2014). In contrast, active restoration requires planting of nursery-grown seedlings, direct seeding, and/or the manipulation of disturbance regimes (for example, thinning and burning) to speed up the recovery process, often at a high cost to establish structural features of the vegetation, reassemble local species composition, and/or catalyze ecological succession (Holl and Aide 2011; Chazdon and Guariguata 2016). High-diversity plantation restoration is currently the most widespread and prevalent approach. Costs range between US$ 7,038 per ha in Brazil to US$ 1,361 per ha in India. India has the most low cost models of tropical forest restoration (Bechara et al. 2021).

Before commencing actual implementation activities, several factors should be in place. Restoration decision-making at local levels is comprised of several factors such as site selection, choice of FLR activities, the pace and schedule of implementation, cost involved, monitoring and evaluation, feedback to address shortcomings. Potential stakeholders should have already been identified and engaged. Nationally, the regions or landscapes targeted for restoration should have been identified and appropriate collaboration and consultations begun with affected local communities (Stanturf et al. 2017).

Species selection

Now-a-days, reforestations are carried out using a larger number of native tree and shrub species, taking into account various objectives viz., plant biodiversity and functionality, soil conservation, climate change mitigation (Herna´ndez et al. 2010; Vallejo 2009). The use of native flora has been considered a priority in afforestation (FAO 1989; van Andel, 1998) but their wide use is hampered by seed availability and technical considerations during nursery period, especially for late-successional species.

Nursery techniques

Nursery culture has an impact on seedling quality and, consequently, survival in the field (Del Campo et al. 2010; Oliet et al. 2009). Morphological and physiological traits of seedlings play an important role in their survival and field performance. Hence, seedling stock quality should focus on enhancing the growth of the root system by improving water holding capacity of the substrate of the root plug, by using adequate containers, and by promoting mechanisms for drought resistance and high water use efficiency (Chirino et al. 2009).

Lesson learnt from previous FLR activities

IUFRO analyzed 17 landscapes in nine countries with Bonn Challenge commitments (three each in Africa, Asia and Latin America) as “snapshots” of FLR implementation. Building on this information, over 60 specific lessons learned were derived from the landscape studies. These were further distilled into the ten overarching lessons.

Central to all FLR initiatives are the two lessons to “utilize appropriate knowledge and methods” and “focus on capacity building and technical assistance”. The first lesson calls for a meaningful combination of traditional and science-based knowledge on forests and restoration, while the latter emphasizes the need for building the necessary capacity of all stakeholders on governance, FLR processes, and field implementation.

The lesson to “include monitoring” is closely related to the issue of capacity building and use of appropriate knowledge. Although short-term monitoring is needed to provide evidence for effective FLR implementation and short-term outputs, long-term monitoring is equally important because FLR is a long-term process and success may be apparent only decades following the initial interventions.

Finally, the lessons to “improve communication” and “strengthen political support” provide important ingredients for transforming landscapes towards more sustainable land uses with enhanced benefits for nature, climate and people. Since FLR operates at large-scale, strong political support at all levels is necessary for FLR to be initiated and especially for long-term success of FLR interventions. For all that to happen, effective communication is a key element of successful multi-stakeholder processes (Stanturf et al. 2020).

FLR opportunities in India

India has committed to large-scale forest protection and tree-based landscape restoration as part of several domestic and international commitments. These include a Bonn Challenge commitment to restore 21 million hectares of degraded and deforested land by 2030 which has now been increased to 26 million hectares. India’s Nationally Determined Contribution (NDC) also aims to improve forest and tree cover at large scales, to sequester an additional 2.5 to 3 billion tons CO2 equivalent by 2030. Official estimates suggest that achieving

the NDC goal requires not only protecting and improving existing forest cover but extending tree cover in 25 to 30 million hectares of mixed land uses, including agriculture (MoEFCC 2017).

Areas having forest cover with a density of more than 40 percent comes under protection areas. These forests can be maintained through protection from risks such as fire, land diversion, and fragmentation. Areas for wide-scale restoration are those where near contiguous tracts of forest and tree cover can be established. The existing forest and tree cover in these areas is less than 40 percent and population density is less than 200 persons per square km. It also includes all plantations irrespective of tree cover density. Mosaic restoration includes agroforestry interventions, such as trees on boundaries, agri-horti-forestry, and farm forestry. Mosaic restoration areas have tree cover density of less than 40 percent and population density of less than 400 persons per sq.km. Protection, wide-scale restoration, and mosaic restoration can generate a wide range of essential provisioning and regulatory ecosystem services, including energy security, biodiversity conservation, secure water flows, and carbon sequestration (Chaturvedi et al. 2018).

A total of 191.91 million hectares, which comprise 58 percent of India's total geographic area, may not be available for the restoration purpose. These include: Permanent ice and snow, sand dunes, scrub and wetlands, water bodies, and swamp forests, Grasslands, National parks, sanctuaries, state reserves, and wildlife reserves, Areas under surface and groundwater irrigation , Urban and built-up areas, and Croplands with more than 40 percent tree canopy cover (Chaturvedi et al. 2018).

In the remaining 138 Mha, the potential for restoration is available. Areas with tree cover density greater than 70 percent are classified as very dense forests and areas with tree cover density between 40 percent and 70 percent as moderately dense forests. These have good tree cover with high potential for natural regeneration. The forests areas with more than 40 percent tree cover density are classified for protection (Chaturvedi et al. 2018). Additionally, mangroves may also be classified under protection. Areas under protection are estimated to be 17.98 million hectares, constituting 5 percent of India's total geographic area.

Wide-scale restoration potential are in areas where the dominant land use is forests, tree cover density is less than 40 percent, and population density is less than 200 persons per sq.km. Ten percent of India's geographic area, equalling 33.6 million ha, is suitable for wide-scale restoration. The remaining areas are suitable for mosaic restoration which includes rainfed croplands. They have less than 40 percent tree cover density and population density of less than 400 people per sq.km (Chaturvedi et al. 2018). The potential for mosaic restoration in India is 87.22 million ha, constituting 26 percent of India's geographic area.

Conclusions

Forest restoration is a highly complex and multi-faceted activity and ongoing initiatives are often inadequate to balance the process of deforestation and forest degradation. Climate is a major driver of disturbances that affect ecosystems, particularly those with vegetation that show large departures from historical conditions. Drought, fire, insects and diseases are common forest stressors whose impacts are being exacerbated by climate change (Bollenbacher et al. 2014).

Protecting forests from degradation, deforestation and fragmentation, and tree-based landscape restoration are globally recognised as cost-effective solutions for combating climate change (Chaturvedi et al. 2018). Increasing vegetation cover and improving productivity in the degraded landscapes reduces the pressure to clear natural forests for agriculture or over-harvest them for fuelwood. Another important aspect of the landscape approach is that it considers social, economic and environmental aspects of the landscape and involves engagement from different sectors, including landowners.

Areas for protection, wide-scale restoration, and mosaic restoration should be identified to support planning for landscape restoration. It may also help in estimating potential for increase in forest and tree cover and the associated carbon sequestration that can be achieved.

Different restoration options should be combined in mosaic landscapes which could involve turning highly degraded areas into sustainable cropland, agroforestry areas or woodlots of native species. Mosaic landscapes provide the greatest opportunity for FLR (Minnemeyer et al. 2011). These are landscapes with moderate human occupancy and generally combine forests or woodlands with agriculture and small settlements, typical of many rural landscapes globally.

Besides providing livelihoods and ecosystem services to local communities, such an approach could also yield a return on the financial investment. The type of planning requires land-use and land-restoration decisions to be made locally with involvement of all the stakeholders. Since most of the tools available are designed for restoration planning at the national level, there is a need for methodologies to help with local decision making.

There is no one-size-fits-all way to successfully implement forest landscape restoration. Complex socio-ecological systems present challenges and opportunities that can best be met with a systematic framework for designing, planning, steering, and monitoring FLR projects to meet diverse needs. Project cycle management is an iterative, adaptive, hierarchical framework with recurring consultations among stakeholders that can enhance the likelihood of FLR success (Stanturf et al. 2029).

Opportunities for restoration exist ubiquitously and are huge in terms of area, although the estimate of their extent is only rough. Mitigation of climate change is a major benefit of restoration, making it an important complement to avoiding additional deforestation and degradation, as well as an opportunity in which many countries can engage, including countries with little or no deforestation left to avoid.

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