WRI INDIA

TECHNICAL NOTE

RESTORATION OPPORTUNITIES ATLAS OF INDIA

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SUMMARY

Protecting forests from degradation, deforestation and fragmentation, and tree-based landscape restoration are globally recognised as cost-effective solutions for combatting climate change. This technical note summarizes the methodology used to prepare the Restoration Opportunities Atlas for India. This Restoration Opportunities Atlas is a first-of-its-kind, web-based, accessible platform that brings together information relevant for India's Nationally Determined Contribution (NDC) to the Paris Agreement, which includes a commitment to sequester additional 2.5 to 3 billion tons CO_2 equivalent by 2030 through increased forest and tree cover. Official estimates suggest that this commitment can only be achieved if existing forests are protected and improved and tree cover is extended by 25 to 30 million hectares. The Restoration Opportunities Atlas brings together best available data and rigorous analysis to answer three questions:

1. Where can forest and tree cover be protected and increased, and how much carbon sequestration will this result in?
2. Which tree-based interventions have been implemented in different states? Who are the principal actors who have implemented these projects?
3. What necessary enabling conditions need to be in place and what risks addressed to ensure achievement of protection and restoration goals?

The Restoration Opportunities Atlas has been developed by WRI India with guidance from a technical working group comprising experts from leading organizations in the environment and development sectors. The atlas will help decision-makers develop broad pathways for achieving the NDC and to plan for landscape restoration at scale to achieve the Sustainable Development Goals.

CONTENTS

WRI Technical Notes document methodology underpinning research publications, interactive applications, and other tools.

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INTRODUCTION

Protecting forests from degradation, deforestation, and fragmentation—along with tree-based landscape restoration, which includes integrating trees in mixed land uses such as forests and cultivated areas, are globally recognized as effective strategies for combatting climate change. 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. 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 CO_2 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). Protecting and improving forest and tree cover is also an essential component of the Sustainable Development Goals (SDG) especially SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 13 (Climate Action) and SDG 15 (Life on Land). With over 700 million people in rural India dependent on forests and agriculture for their livelihoods, improving forest and tree cover at scale can strengthen the rural economy and improve livelihoods of local communities including women and tribal and other marginalized groups.

To support strategic planning for forest protection and landscape restoration, the Restoration Opportunities Atlas brings together best available data and rigorous analysis to:

1. Identify where and to what extent forest and tree cover can be improved as well as to estimate the potential for carbon sequestration through these improvements;

2. Present a selection of past and on-going restoration initiatives in the country that can be replicated and scaled up, along with key actors who have supported implementation of the project; and

3. Indicate the presence of key enabling conditions that underpin the success of restoration interventions, as well as conditions that pose a risk to restoration success.

The Restoration Opportunities Atlas has been developed by WRI India with guidance from a Technical Working Group (TWG) comprising experts from leading organizations in the environment and development sectors. See Appendix 1 for a list of TWG members. This technical note is divided into three parts. The first part provides an overview of the architecture of the Restoration Opportunities Atlas, including its various sections and the layers within these sections. The second part of the note focuses on the datasets that were used in preparing different spatial layers, their resolution, and whether they were sourced from public sources or shared by partners. The third part of the technical note presents the methodology for each of the spatial layers in the Restoration Opportunities Atlas.

OVERVIEW OF THE ATLAS

The Restoration Opportunities Atlas is built using the Global Forest Watch Map Builder tool which is powered by ArcGIS.

The atlas is organized into seven sections, each comprising one or more spatial layers (Table 1).

Users can view and download national as well as state level statistics. The state-level report contains information across multiple layers. Additionally, section 4 also contains links to a database of past and ongoing restoration projects from different parts of the country.

DATASETS

The atlas utilizes publicly available data as well as data shared by partners. While many publicly sourced datasets were global in coverage, national-level datasets were largely shared by partners under different data-sharing agreements. The resolution of the datasets varied from 30m to more than 1km, and many layers comprised point data. The layers on landscape restoration opportunities, potential for increase in forest and tree cover, and potential for increase in above-ground carbon sequestration are in raster format, and the remaining layers are in vector format. An example of the different types of datasets used for analysis is provided in Table 2, which lists the datasets underpinning estimates of the potential for protection and wide-scale and mosaic restoration. A similar list of all datasets used is in Appendix 2.

Table 1 | **Structure of the Restoration Opportunities Atlas**

SECTION	SPATIAL LAYERS
Landscape restoration opportunities	Forest and landscape restoration opportunities State-wise forest and landscape restoration opportunities
Potential for increase in forest and tree cover	Potential for increase in forest and tree cover where maximum tree cover in cultivated areas is capped at 20% Potential for increase in forest and tree cover where maximum tree cover in cultivated areas is capped at 40%
Potential for increase in above-ground carbon sequestration	Potential for increase in above-ground carbon sequestration where maximum tree cover in cultivated areas is capped at 20% Potential for increase in above-ground carbon sequestration where maximum tree cover in cultivated areas is capped at 40% State-wise potential for increase in above-ground carbon sequestration
Past and ongoing initiatives	Forest protection and landscape restoration interventions Actors involved in implementing forest and landscape restoration
Risk factors for restoration	Potential risk factors in the states Incidents of forest fire Diversion of forest land Land and forest conflicts
Tenure and resource rights	Percentage of recorded forest area under JFM Potential for Community Forest Resource Rights (CFR) Recognized CFR areas Fifth and Sixth schedule areas
Finance for forest protection and tree-based restoration	Allocation of public finance to states excluding MGNREGS Allocation under MGNREGS States' share in the CAF

Source: WRI India.

Table 2 | **Datasets for the Map of Potential for Protection, Wide-scale Restoration, and Mosaic Restoration**

Layer	Description	Source	Coverage	Resolution
Land Use and Land Cover (LULC)	Classified LULC layer consisting of 19 land use classes*	Roy et al. 2015	National	60m
Tree Cover	Tree cover data from LANDSAT	Global Landcover Facility 2015	Global	30m
Protected Areas	National parks, sanctuaries and other protected areas notified under the Wildlife Protection Act, 1972.	UNEP-WCMC 2018	Global	Not Applicable
Irrigation Status	Cropped areas under irrigation	Published study on irrigated areas identified using MODIS data for both surface and ground water irrigation. (Ambika et al. 2016)	National	250m
Human Footprint	Covers human population pressure (population density), human land use and infrastructure (built-up areas, night lights), and human access (coastlines, roads, railroads, navigable rivers).	Columbia University Center for International Earth Science Information Network (CIESIN) (WCS and CIESIN 2005) Roy et al. 2015	Global	1km
Human Population	Population data from Census, 2011	Government of India 2011 (available on worldpop.org)	National	1km

Source: WRI India.

Note: * The LULC layer was developed from the vegetation map developed by Roy et al, (2015), which consists of 141 vegetation classes. These classes were aggregated into 16 LULC categories. Appendix 3 presents the LULC categories.

METHODOLOGY FOR SPATIAL LAYERS

Landscape Restoration Opportunities

The landscape restoration opportunities map identifies the potential for protection, wide-scale restoration, and mosaic restoration in India. The methodology for this layer was developed by WRI India and Strand Life Sciences.

Notably, for the purposes of this atlas, protection areas have forest cover with a density of more than 40 percent. 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 is the integration of trees in a patchwork of different land uses including rainfed cultivated areas. 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.

The first step in developing the landscape restoration opportunities map was to exclude areas based on several criteria summarized in Table 3.

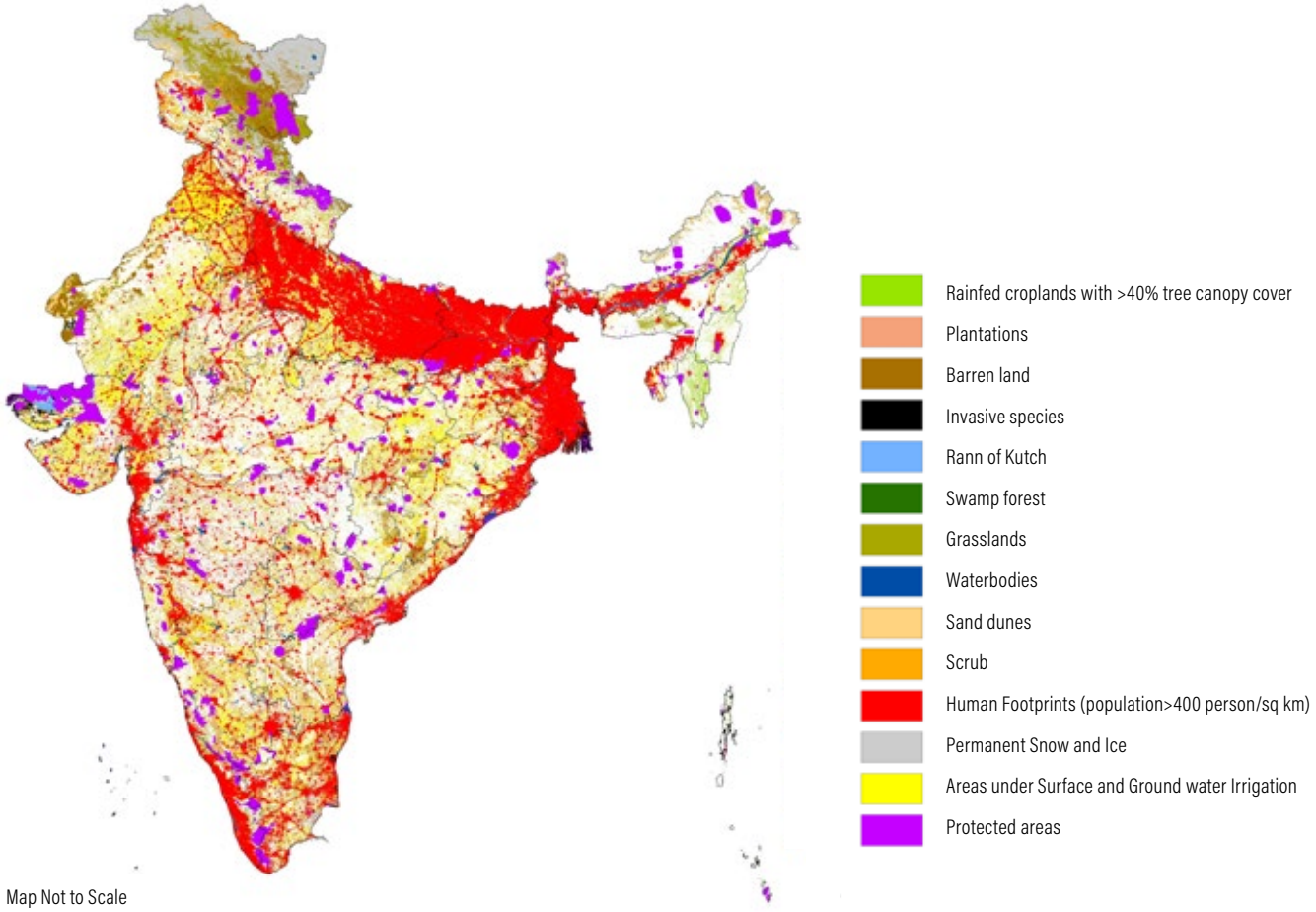
A total of 191.91 million hectares, which comprise 58 percent of India's total geographic area, were excluded. The map of exclusion areas is provided in Map 1. In the remaining 138 Mha, the potential for protection

Table 3 | **Areas Excluded from the Restoration Opportunities Assessment**

S. No	Criteria	Reason
1	Permanent ice and snow, sand dunes, scrub and wetlands, water bodies, and swamp forests	The biophysical conditions of these areas do not support tree-based restoration interventions.
2	Grasslands	Grasslands were excluded due to their high ecological importance, and grassland restoration requires a range of different interventions that may or may not involve tree-based interventions. Grasslands were identified from the LULC layer.
3	National parks, sanctuaries, state reserves, and wildlife reserves	Principles of wildlife management in national parks, sanctuaries, state reserves, and wildlife reserves may make tree-based restoration unsuitable. The boundaries of protected areas were obtained from the UNEP-WCMC database.
4	Areas under surface and groundwater irrigation	Irrigated areas were excluded from the restoration opportunities assessment due to their major role in ensuring food security. Based on guidance from the TWG, WRI India decided that the current broad-scale analysis cannot address the nuances in trade-offs between food security and restoration adequately. Therefore, irrigated areas identified using the base layer on irrigation status were excluded (Ambika et al. 2016).
5	Urban and built-up areas	The Census of India classifies areas with over 400 persons/sq.km as urban areas (Government of India 2011). Analysis of restoration opportunities in urban areas required in-depth analysis of potential for home gardens, linear plantations, and so on. Because such analysis was not possible in the current assessment, areas with population density of more than 400 people/sq.km were excluded. These regions are better suited for analysis at the subnational level. These areas were identified by combining information from human footprint (WCS and CIESIN 2005) and human population (Government of India 2011).
6	Croplands with more than 40 percent tree canopy cover	A preliminary literature review indicates that over 34 different types of agroforestry interventions are practiced in India, including boundary plantations, alley cropping, block plantation, WADI[1], and so on. For the restoration opportunities assessment, croplands with more than 40 percent tree cover were excluded because these areas already support high tree cover, and further increases may result in trade-offs with food security. We recognize that some interventions may lead to tree cover as high as 70 to 90 percent (Shah 2005), and a national level analysis is not possible with the available data. Orchards and plantations have been excluded as well. These areas were identified by overlaying the LULC and tree cover layers.

Source: WRI India.

Map 1 | **Areas Excluded from the Restoration Opportunities Assessment**



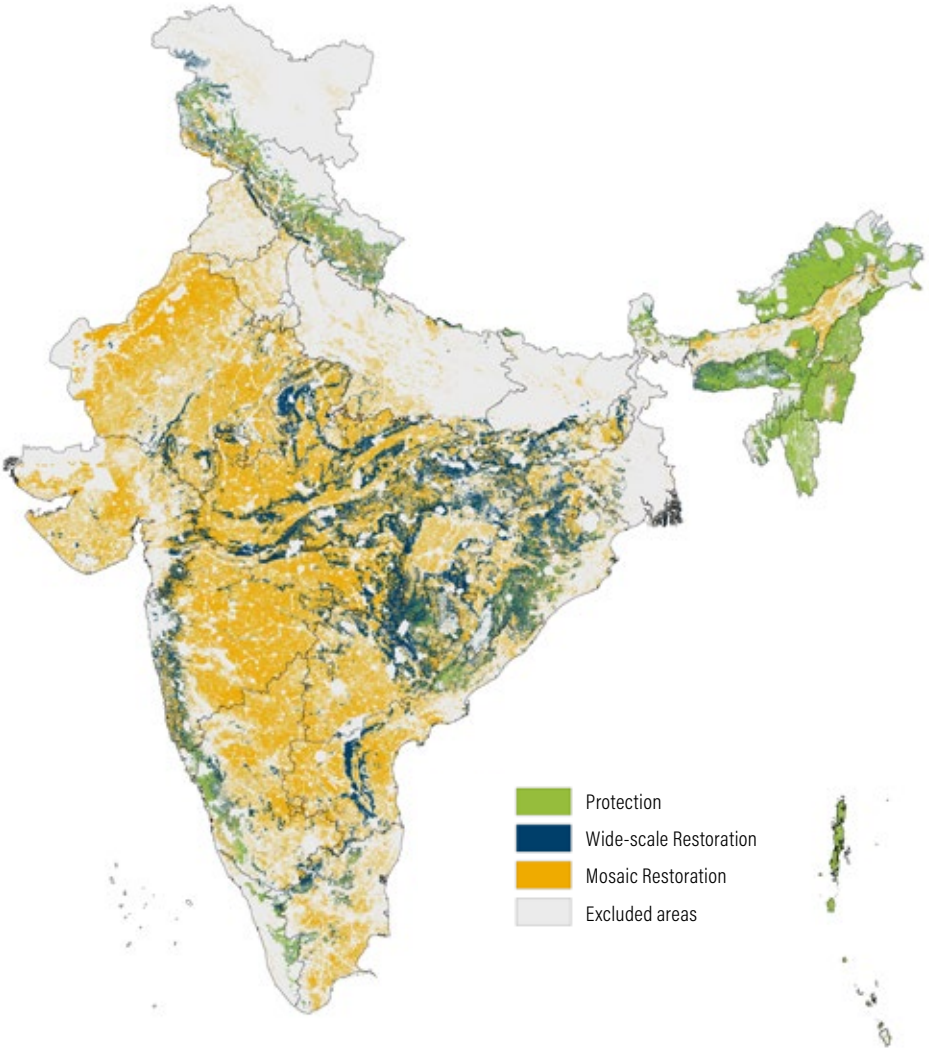
Map Not to Scale

was identified using the LULC and tree cover data. The Forest Survey of India (FSI) classifies areas with tree cover density greater than 70 percent as very dense forests and areas with tree cover density between 40 percent and 70 percent as moderately dense forests (FSI 2017). Very dense and moderately dense forests have good tree cover with high potential for natural regeneration. During analysis, the LULC layer was overlaid with the tree cover layers to identify forests areas with more than 40 percent tree cover density. These areas were classified for protection. Additionally, mangroves were also classified under protection. Areas under protection were estimated to be 17.98 million hectares, constituting 5 percent of India's total geographic area.

Wide-scale restoration potential was identified in areas where the dominant land use was forests, tree cover density was less than 40 percent, and population density was less than 200 persons per sq.km. Ten percent of India's geographic area, equalling 33.6 million ha, was identified as suitable for wide-scale restoration. The remaining areas were classified as suitable for mosaic restoration. These included rainfed croplands. They have less than 40 percent tree cover density and population density of less than 400 people per sq.km. The potential for mosaic restoration in India is 87.22 million ha, constituting 26 percent of India's geographic area.

The map of opportunities for protection and wide-scale and mosaic restoration is provided in Map 2.

Map 2 | **Forest Protection and Landscape Restoration Opportunities**



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Potential for increase in forest and tree cover

This section analyzes the potential for increase in forest and tree cover in protection, wide-scale restoration, and mosaic restoration areas. The potential for increase in forest and tree cover was estimated as the difference between maximum tree cover recorded in 2015 and existing tree cover in 2015:

$$T\Delta = Tmax - Tp$$

where TΔ is the potential for increase in forest and tree cover, T max is the maximum forest and tree cover in 2015, and T p is the present forest and tree cover in 2015. The potential for increase in forest and tree cover is expressed as a percentage.

The methodology followed for estimating increase in forest and tree cover in protection, wide-scale restoration, and mosaic restoration is described as:

AREAS FOR PROTECTION

The vegetation map of Roy et al. (2015) identified 52 forest classes. These forest classes were overlaid with 10 biogeographic zones of India (Rodgers and Panwar 1988). The details of vegetation classes and biogeographic zones is provided in Appendix 4. The highest forest and tree cover in each vegetation class under each biogeographic zone in 2015 was assumed as the maximum forest and tree cover (T max). Landsat tree cover (2015) data were used to identify current forest and tree cover at 60m pixel (T p). Using the formula mentioned above, the potential for increase in forest and tree cover (TΔ) was estimated.

AREAS FOR WIDE-SCALE RESTORATION

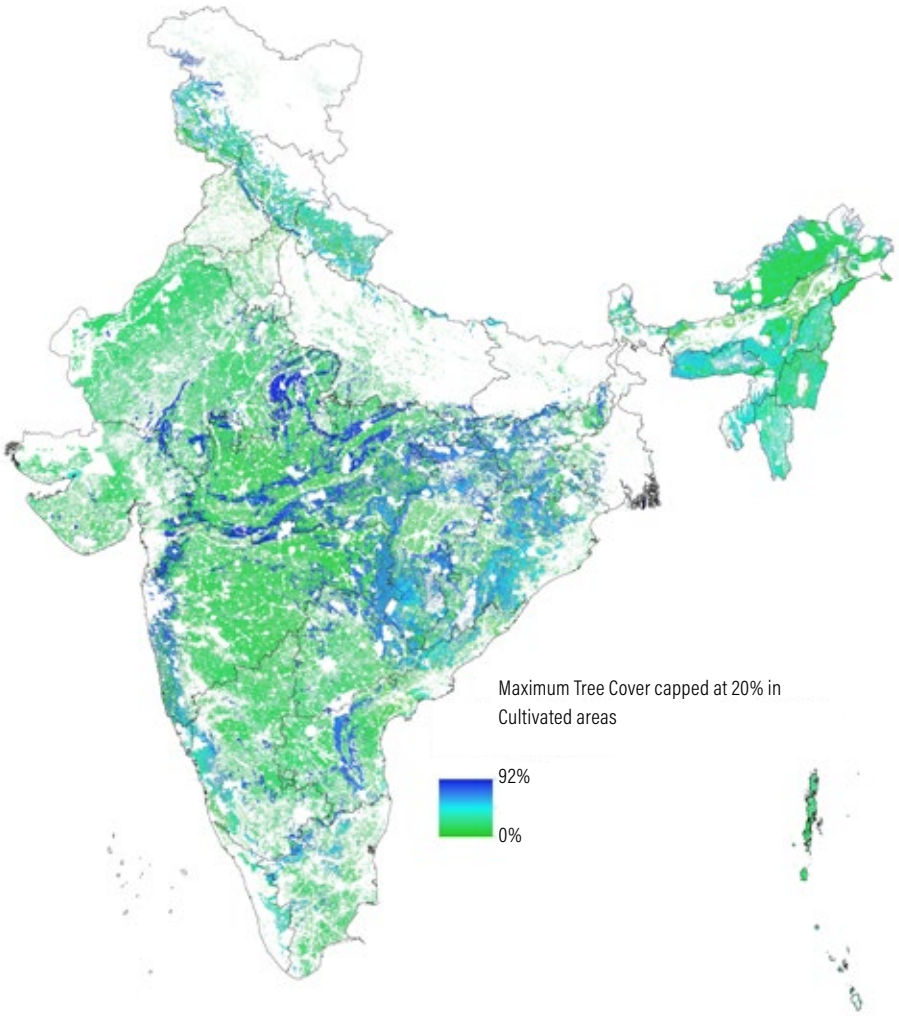
The process for estimating potential for increase in forest and tree cover in wide-scale restoration areas was the same as that described above for protection.

AREAS FOR MOSAIC RESTORATION

For areas under mosaic restoration, two scenarios were developed to identify the maximum possible forest and tree cover (T max). In the first, T max was assumed to be 20 percent in cultivated areas. This limit was considered based on the Planning Commission's articles on farm and agroforestry in India, which suggests that 60 to 100 trees per hectare, approximately 20 percent tree cover, is common practice in agroforestry systems (Saxena 2015). In the second scenario, T max was considered to be 40 percent in cultivated areas, because cultivated areas with more than 40 percent tree cover were excluded from the restoration opportunities assessment. For other lands, T max was based on the highest forest and tree cover in each biogeographic zone. Landsat tree cover (2015) data were used to identify current tree cover at 60m pixel (T p). The potential for increase in forest and tree cover (TΔ) was estimated using the above formula.

The atlas consists of two spatial layers that present the potential for increase in forest and tree cover. The first presents potential for increase in forest and tree cover through protection and wide-scale and mosaic restoration where maximum tree cover in cultivated areas is capped at 20 percent. The second presents the potential for increase in forest and tree cover through protection and wide-scale and mosaic restoration where maximum tree cover in cultivated areas is capped at 40 percent. The layers are presented in Map 3 and Map 4. It should be noted that the analysis considers native trees for estimation of potential for increase in forest and tree cover because these can not only support carbon sequestration but also contribute to a range of co-benefits. These co-benefits include biodiversity conservation; improvement of soil health and erosion control; and provisioning of fuelwood, fodder, and nontimber forest produce for local communities.

Map 3 | **Potential for Increase in Forest and Tree Cover Through Protection and Wide-scale and Mosaic Restoration Where Maximum Tree Cover in Cultivated Areas is Capped at 20 Percent**



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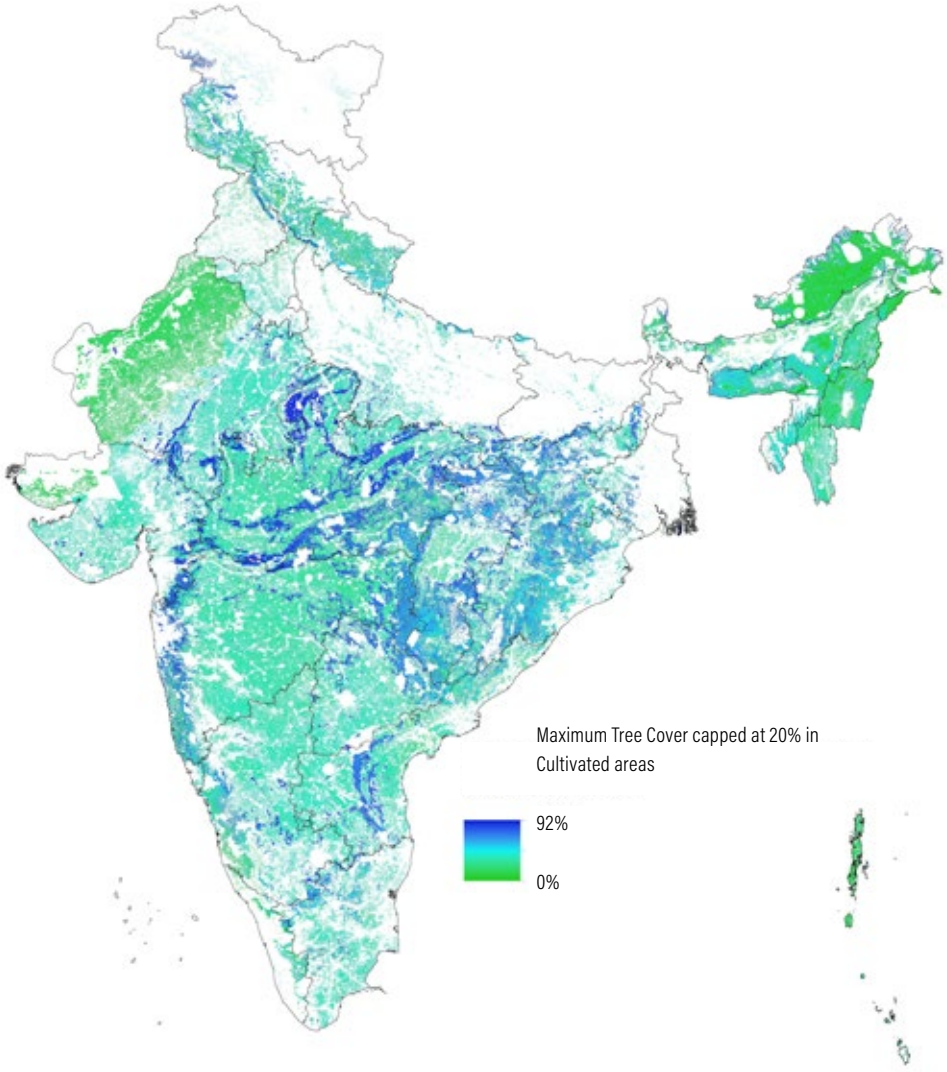
Map 4 | **Potential for Increase in Forest and Tree Cover Through Protection and Wide-scale and Mosaic Restoration Where Maximum Tree Cover in Cultivated Areas is Capped at 40 Percent**



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Potential for increase in above-ground carbon sequestration

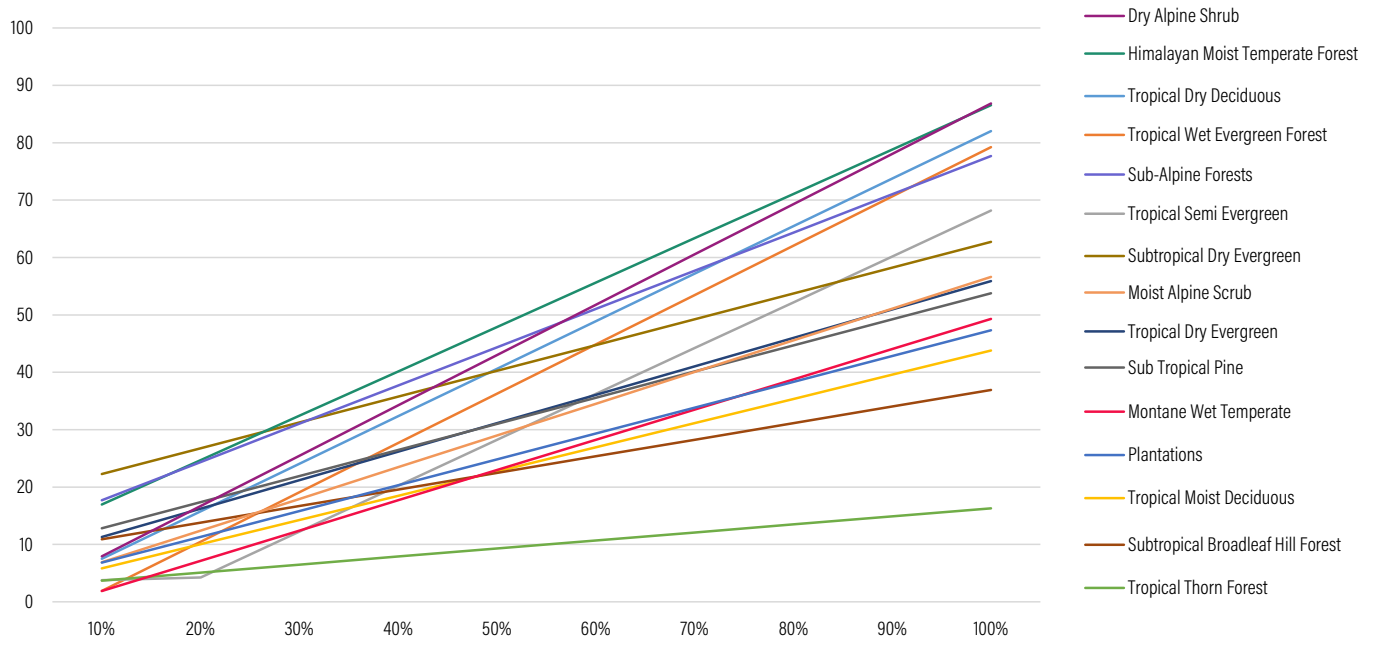
This section provides information on above-ground carbon sequestration that can be achieved through protection, wide-scale restoration, and mosaic restoration.

AREAS FOR PROTECTION

As a first step, the 52 forest classes identified by Roy et al. (2015) were merged into the 16 forest types and plantations listed by FSI for biomass and carbon estimation. This was done based on dominant vegetation type. Notably, 10 types could not be merged due to ambiguities in vegetation. The total area covered by these 10 types was negligible, and the problem was addressed by merging the areas into the nearest forest type. The reclassification of the vegetation map enabled application of the forest types and carbon stock values calculated by FSI, based on the methodology developed by the Intergovernmental Panel on Climate Change.[2] See Appendix 5 for the carbon stock values calculated by FSI for different forest types used in this analysis.

Using the methodology developed by Zomer et al. (2016) for calculating biomass carbon, the carbon stock values were applied to different tree cover percentages estimated in the layer on potential for increase in forest and tree cover. FSI's average carbon stock values for three different tree cover categories—namely, very dense, moderately dense, and open forests—for the 16 forest types were considered. These average carbon values were assigned to the mean tree cover in each tree cover category. Using linear regression analysis, the

Figure 1 | **Linear Regression Analysis for Carbon Stock**



carbon stock values for tree cover percentages from 10 to 100 percent were estimated (see Figure 1).

In the final step, the carbon stock values corresponding to the percentage of tree cover were used to estimate the potential to improve above-ground carbon stock.

AREAS FOR WIDE-SCALE RESTORATION

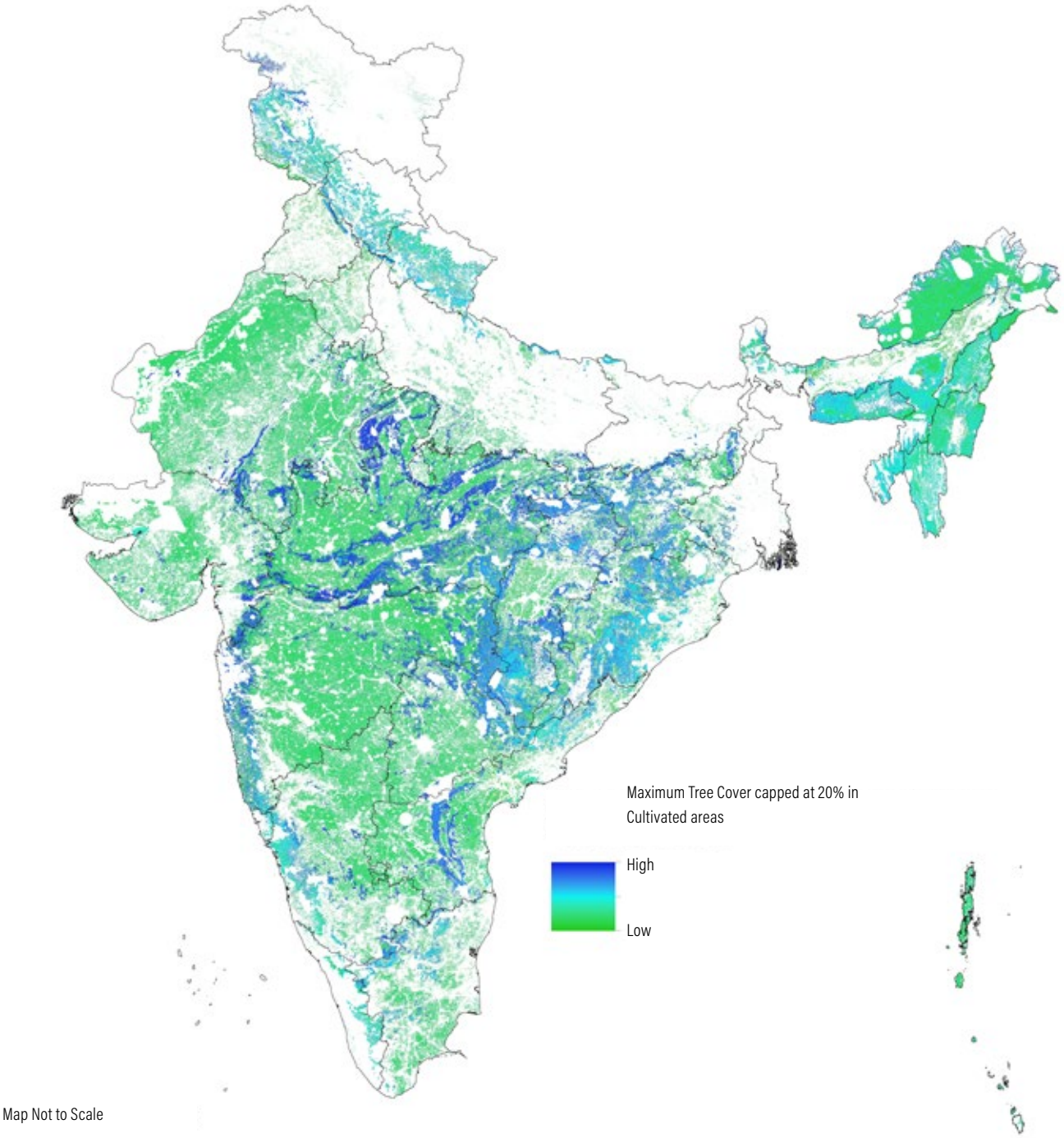
The above methodology used for carbon sequestration through protection was also used for estimating above-ground carbon sequestration potential through wide-scale restoration.

AREAS FOR MOSAIC RESTORATION

For areas under mosaic restoration, the prominent forest types in each biogeographic zone were identified. The average carbon stock value for each identified forest type was used to develop the linear regression model and estimate the potential for improving above ground carbon sequestration (using the same process followed for areas under protection and wides-scale restoration). Similar to the analysis carried out for potential increase in forest and tree cover, the potential for carbon sequestration is presented for two scenarios: tree cover capped at 20 percent in cultivated areas and 40 percent in cultivated areas.

The atlas comprises two spatial layers on potential to increase above-ground carbon sequestration. The first, shows the potential for increase in above-ground carbon sequestration through protection and wide-scale and mosaic restoration where maximum tree cover in cultivated areas is capped at 20 percent. The second layer presents the potential for increase in above-ground carbon sequestration through protection and wide-scale and mosaic restoration where maximum tree cover in cultivated areas is capped at 40 percent. The spatial layers are presented as Map 5 and Map 6.

Map 5 | **Potential for Increase in Above-Ground Carbon Sequestration through Protection and Wide-scale and Mosaic Restoration where Maximum Tree Cover in Cultivated Areas is Capped at 20 Percent**



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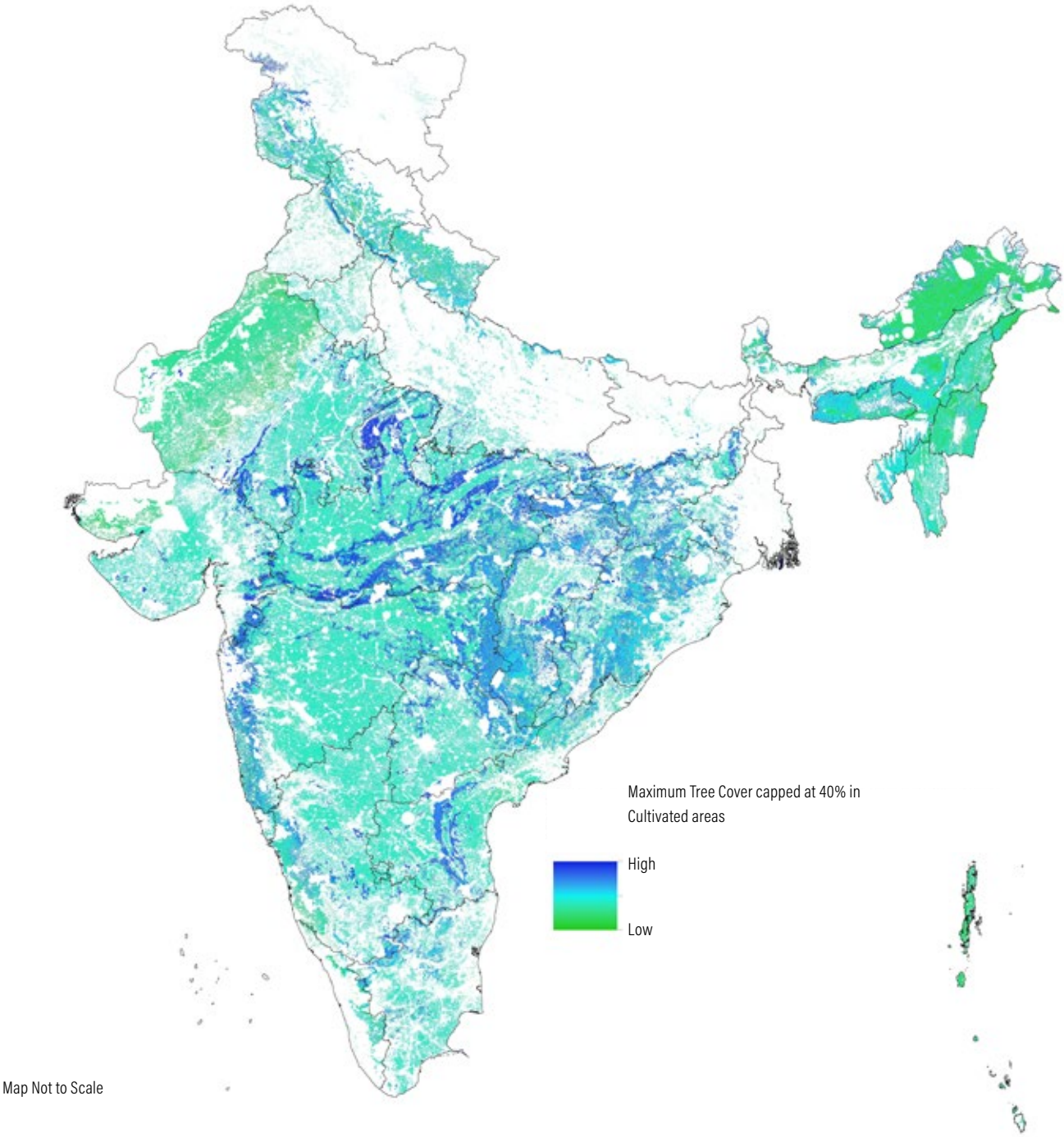
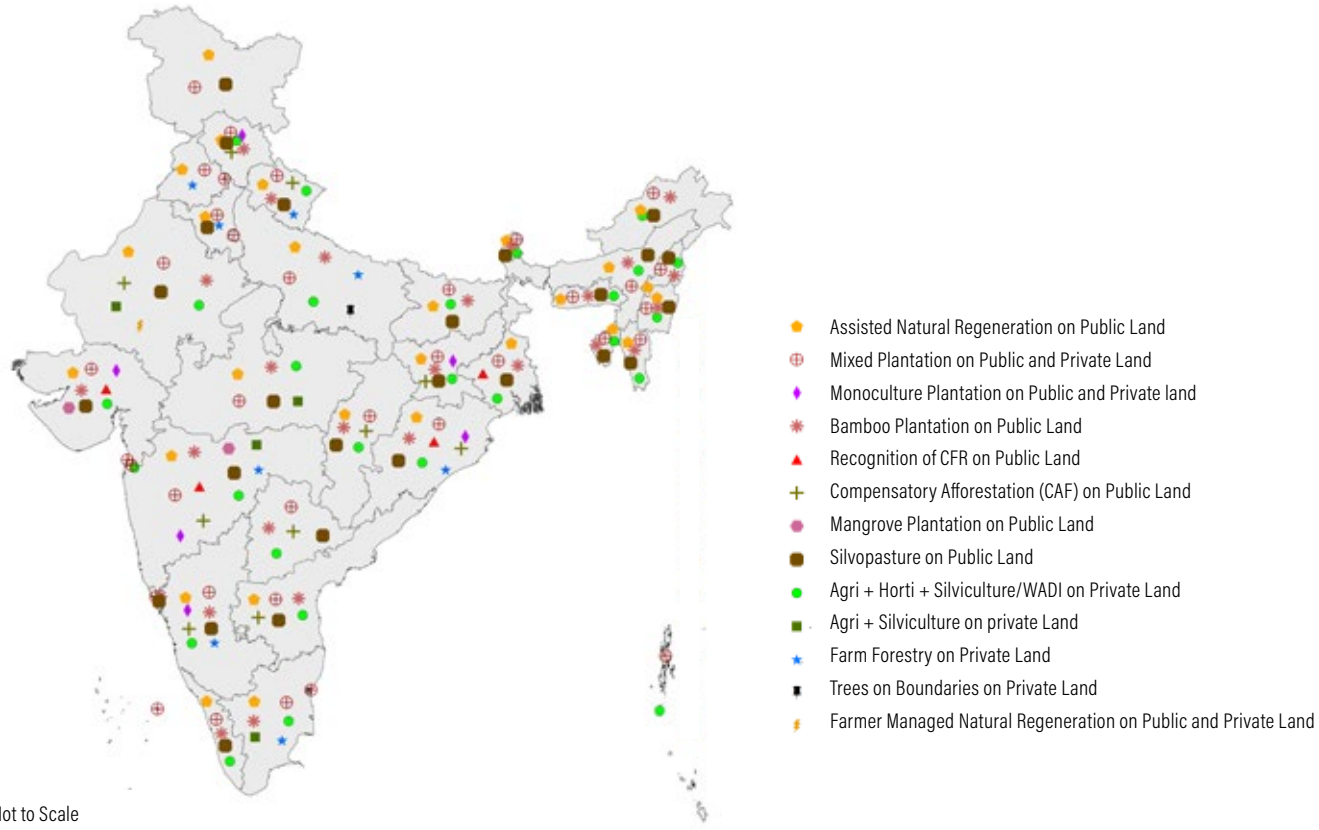
Map 6 | **Potential for Increase in Above-Ground Carbon Sequestration through Protection and Wide-scale and Mosaic Restoration where Maximum Tree Cover in Cultivated Areas is Capped at 40 Percent**



Past and ongoing initiatives

India has a rich history of tree-based restoration interventions that have been implemented by multiple actors in different parts of the country. This section of the atlas comprises two layers. The first presents information on the different restoration interventions found in the states. These interventions include assisted natural regeneration, mixed plantation, monoculture plantation, agri-horti-silviculture, agri-silviculture, farm forestry, silvopasture, bamboo plantation, mangrove plantation, farmer-managed natural regeneration, and afforestation funded through Compensatory Afforestation Fund (CAF). The second layer focuses on the different implementing actors in the states. These actors include government agencies, NGOs, local communities, the private sector, and combinations of these actors involved in implementation. The layers are presented in Map 7 and Map 8.

Map 7 | Past and Ongoing Initiatives - Forest Protection and Landscape Restoration Interventions



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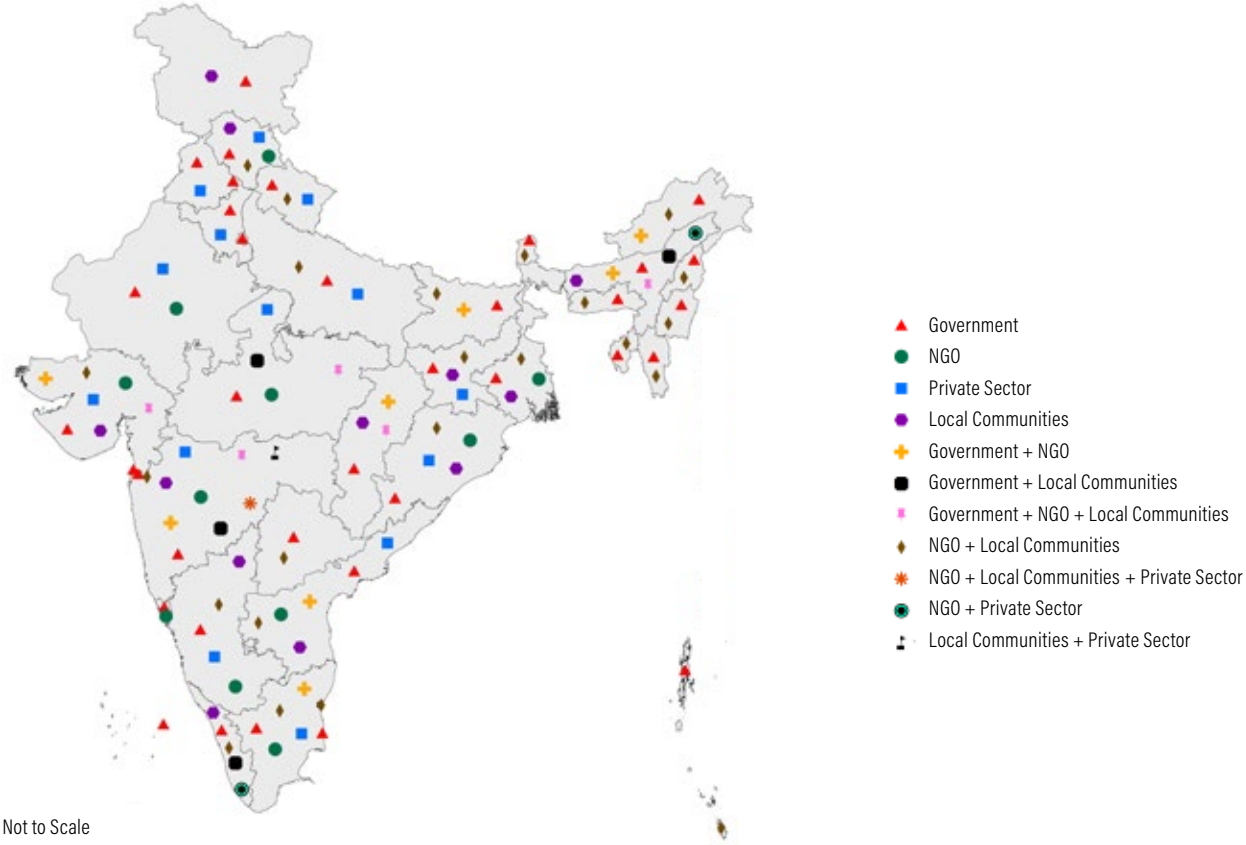
Map 8 | Past and Ongoing Initiatives - Actors Involved in Implementing Forest Protection and Landscape Restoration



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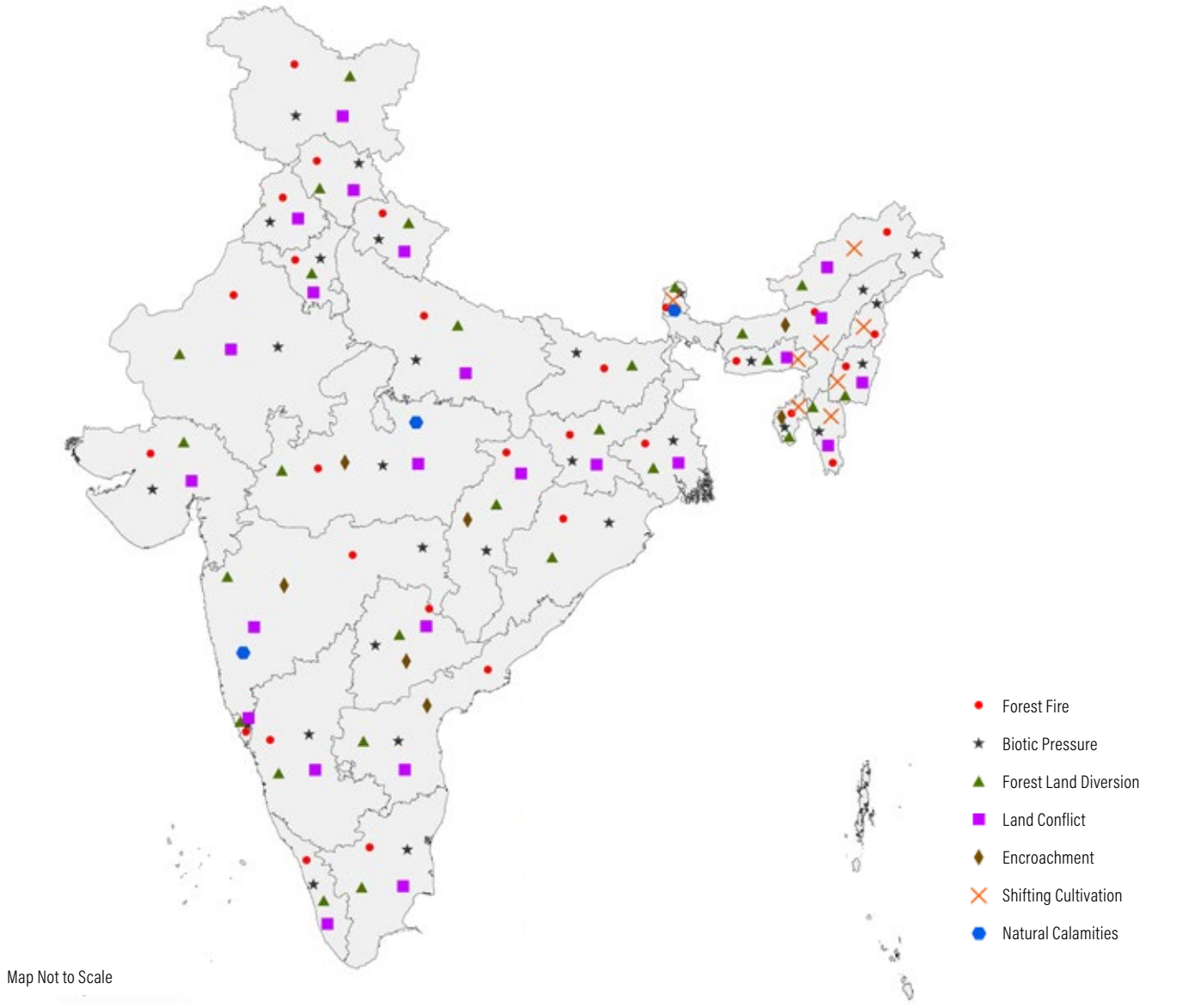
As mentioned earlier, the section on past and on-going interventions also includes a database of over 200 projects and programs with information on their locations, types of interventions, area covered, actors involved, objectives of the initiative, benefits realized, and business models developed. The methodology for the case studies involved secondary literature review as well as primary data collection through questionnaires/ interviews with experts and practitioners. Additionally, the database includes information collected by the International Union for Conservation of Nature (IUCN) on the status of government plans such as the National Afforestation Programme Plan, National Mission for Green India (GIM), and Twenty Point programme. The database of past and on-going initiatives is work in progress and will be updated periodically.

Risk factors for restoration

This section provides information on four types of risks to restoration.

- **Overview of potential risk factors in the states:**
  Different factors that affect restoration were inferred from FSI's reports (FSI 2013; FSI 2015; FSI 2017). These factors include forest land diversion, shifting cultivation, natural calamities, encroachments, and biotic pressures. Other potential risk factors included are incidents of forest fire (Parliament. Lok Sabha 2014; Parliament. Lok Sabha 2016; Parliament. Lok Sabha 2017), forest land diversion (MoEFCC 2018), and land and forest conflicts (Land Conflict Watch 2018). The layer is presented as Map 9. This section also presents more detailed information on select threats in separate layers.

Map 9 | **Potential Risk Factors in the States**

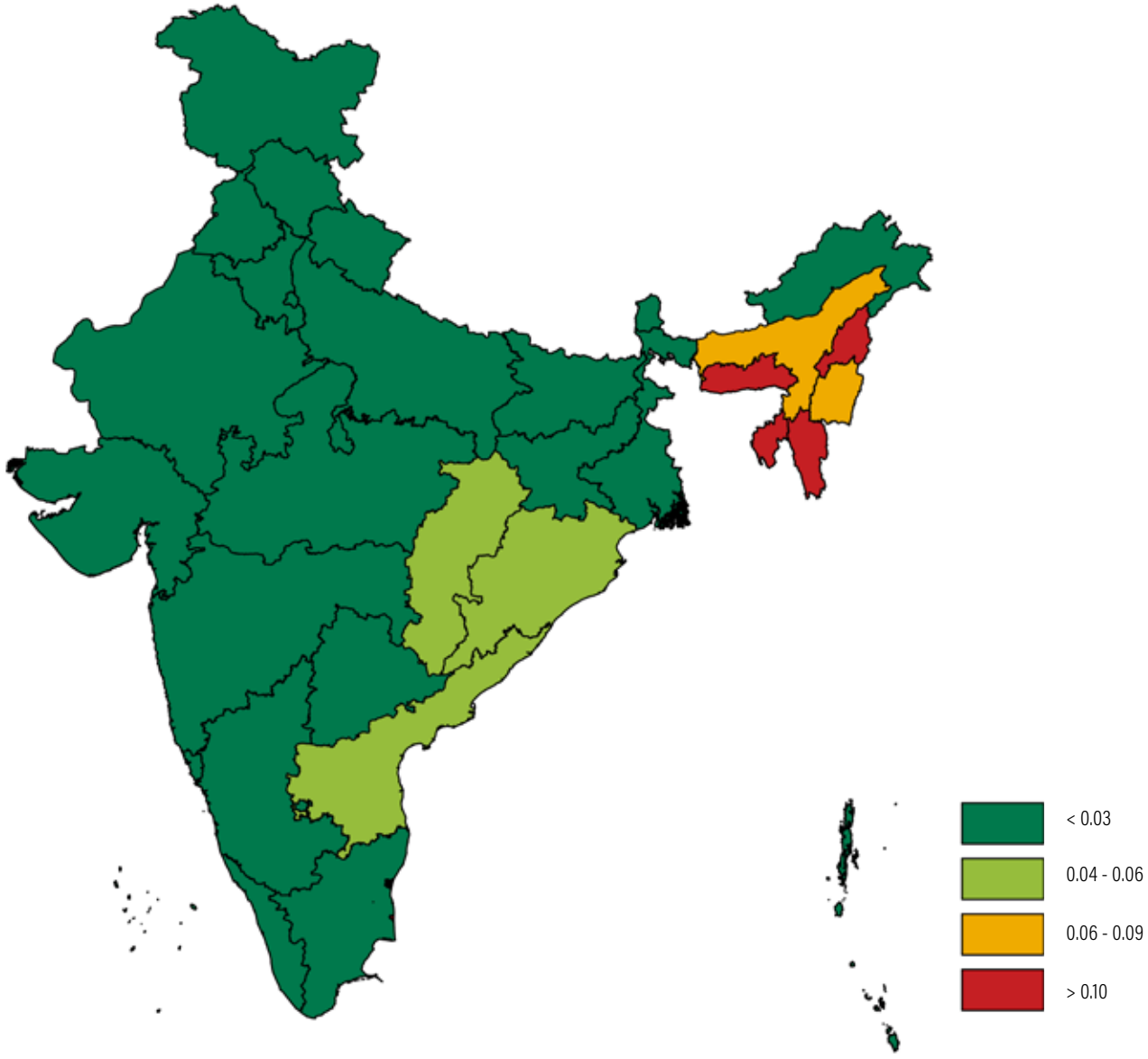


- **Incidents of forest fires:** Forests fires are one of the major threats to forest health in India, with FSI recognizing as much as 64 percent of recorded forest areas as being prone to fires (FSI 2015). The layer on forest fires presents the average number of forest fires between the years 2011 and 2017 per square km recorded forest area for each state (Parliament. Lok Sabha 2014; Parliament. Lok Sabha 2016; Parliament. Lok Sabha 2017). Based on the incidents of forest fires, the layer classifies states into four categories. The layer is presented as Map 10.

  The threat of fires was not considered for mosaic restoration areas because fires are a part of the agriculture practice in many regions. These fires can be carefully managed to minimize the impact on trees in the vicinity.

- **Diversion of forest land:** Forest lands in India are diverted for development purposes, such as setting up of industries, roads, irrigation projects, and so on. The atlas displays the forest land diverted in each state for the period 2000 to 2017. It should be noted that disaggregated data were not available for Andhra Pradesh and Telangana, and the division

Map 10 | Average Number of Forest Fire Incidents per sq.km between 2011 and 2017

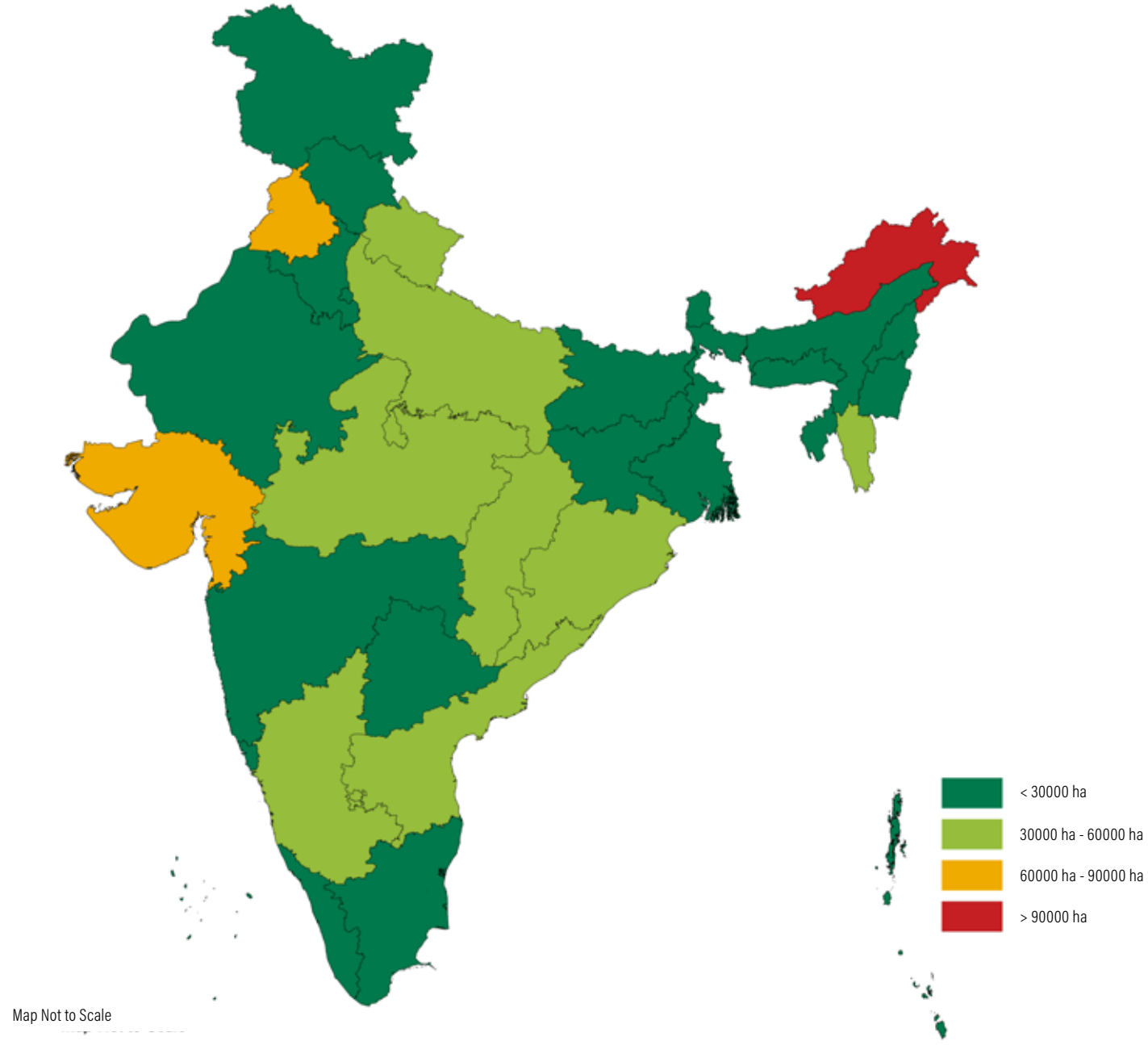


Map Not to Scale

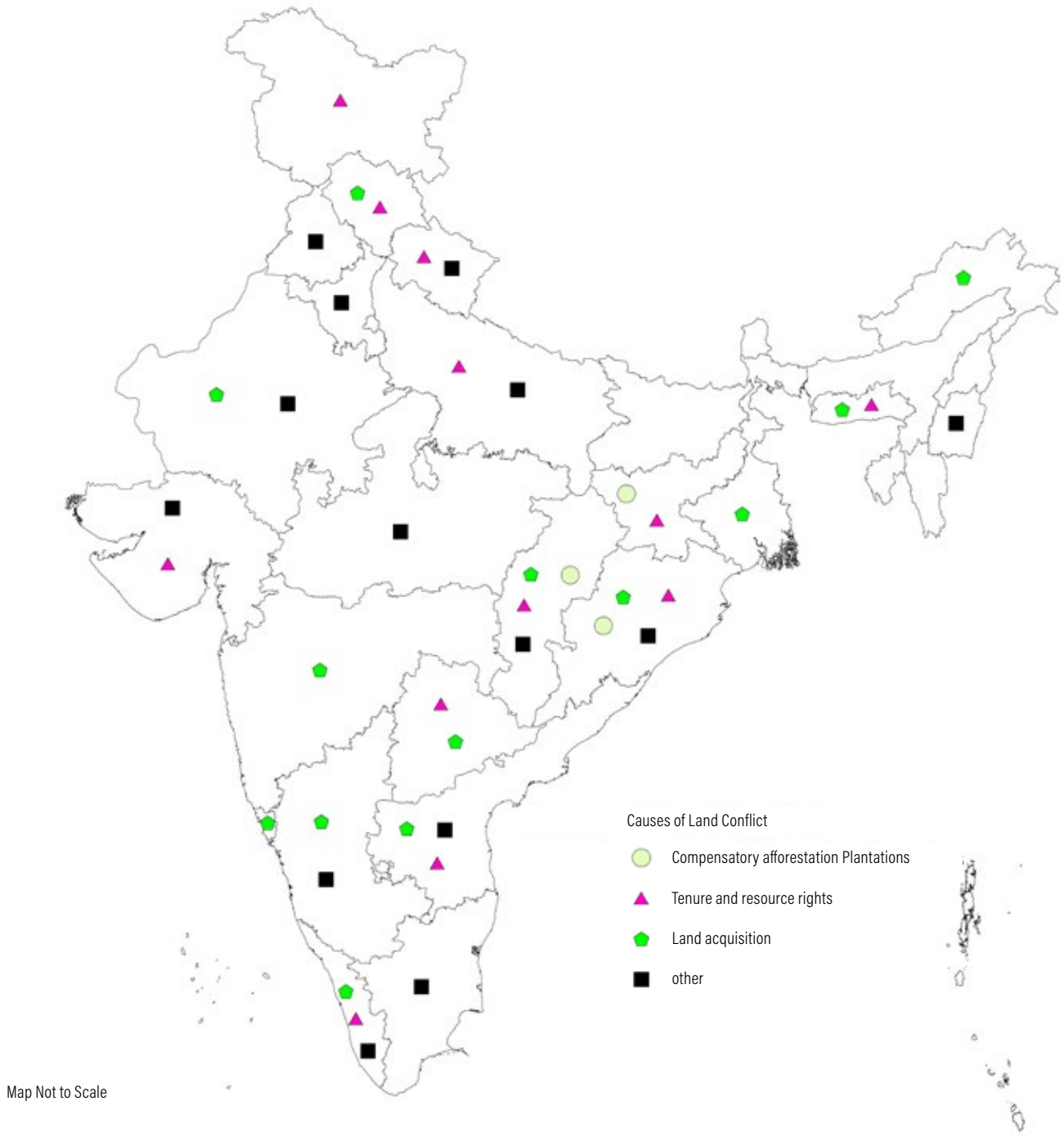
of forest land diverted was proportionate to the CAF provided to the two states.[3] The layer was developed based on data from the Government of India that was compiled and shared by BIPP-ISB. The layer classifies states into the following four categories based on forest land diverted: less than 30000 ha, 30,000 to 60,000 ha, 60,000 to 90,000 ha, and greater than 90,000 ha. The layer is presented as Map 11.

- **Land and forest conflicts:** The atlas uses data from Land Conflict Watch to identify areas with conflicts that could potentially affect restoration. Land Conflict Watch is a research-based data journalism project that maps and analyzes ongoing land conflict in India. For an overview of the methodology followed by Land Conflict Watch, see the portal.[4] The layer identifies conflict under four categories: CAF-related conflicts, tenure and resource rights-related conflicts, land acquisition conflicts, and other conflicts. Results are aggregated at the state level. It should be noted that data are not available for eight states. This is because Land Conflict Watch is an ongoing initiative, and data are yet to be gathered for these states. The layer is presented as Map 12.

Map 11 | **Area of Forest Land Diverted between 2000 and 2017 in ha**



Map 12 | **Land and Forest Conflicts**



TENURE AND RESOURCE RIGHTS

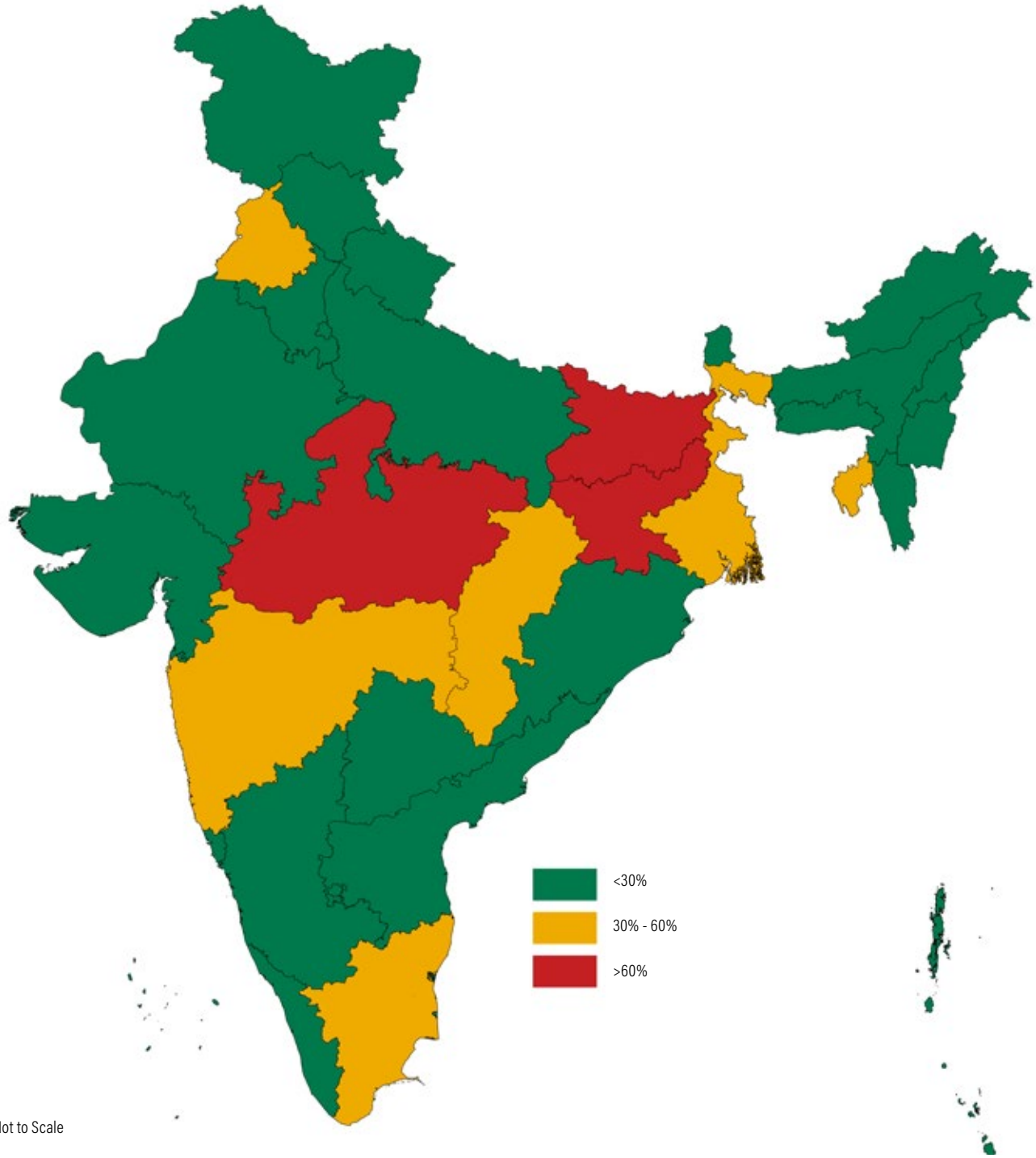
Secure tenure and resource rights are important enabling conditions for successful restoration (Hanson, et al. 2015). Globally, there is growing evidence that community forest lands with secure tenure are often linked to lower deforestation rates, significant increase in forest cover, and sustainable production of timber and other forest products (Ding et al. 2016). The atlas provides information on tenure and resource rights through three layers:

1. **Percentage of Recorded Forest Area under Joint Forest Management:** JFM is a participatory approach for management of state-owned forest lands in India. It was introduced as a national policy in 1990 and adapted by the states to suit their contextual specificities.[5] JFM enables local communities to enter into agreements with state forest departments to jointly protect and benefit from adjacent forest lands. When communities participate in JFM, they are entitled to benefits such as fodder, fuelwood, nontimber

forest produce, and small timber, as well as a share in the regenerated timber whenever it is harvested. At present, there are more than 118,213 JFM Committees managing 22.94 million hectares of recorded forest area (MoEFC 2011). The layer on JFM classifies states into three categories based on the percentage of recorded forest area under JFM. The categories are less than 30 percent, 30 to 60 percent and above 60 percent. The layer is presented as Map 13.

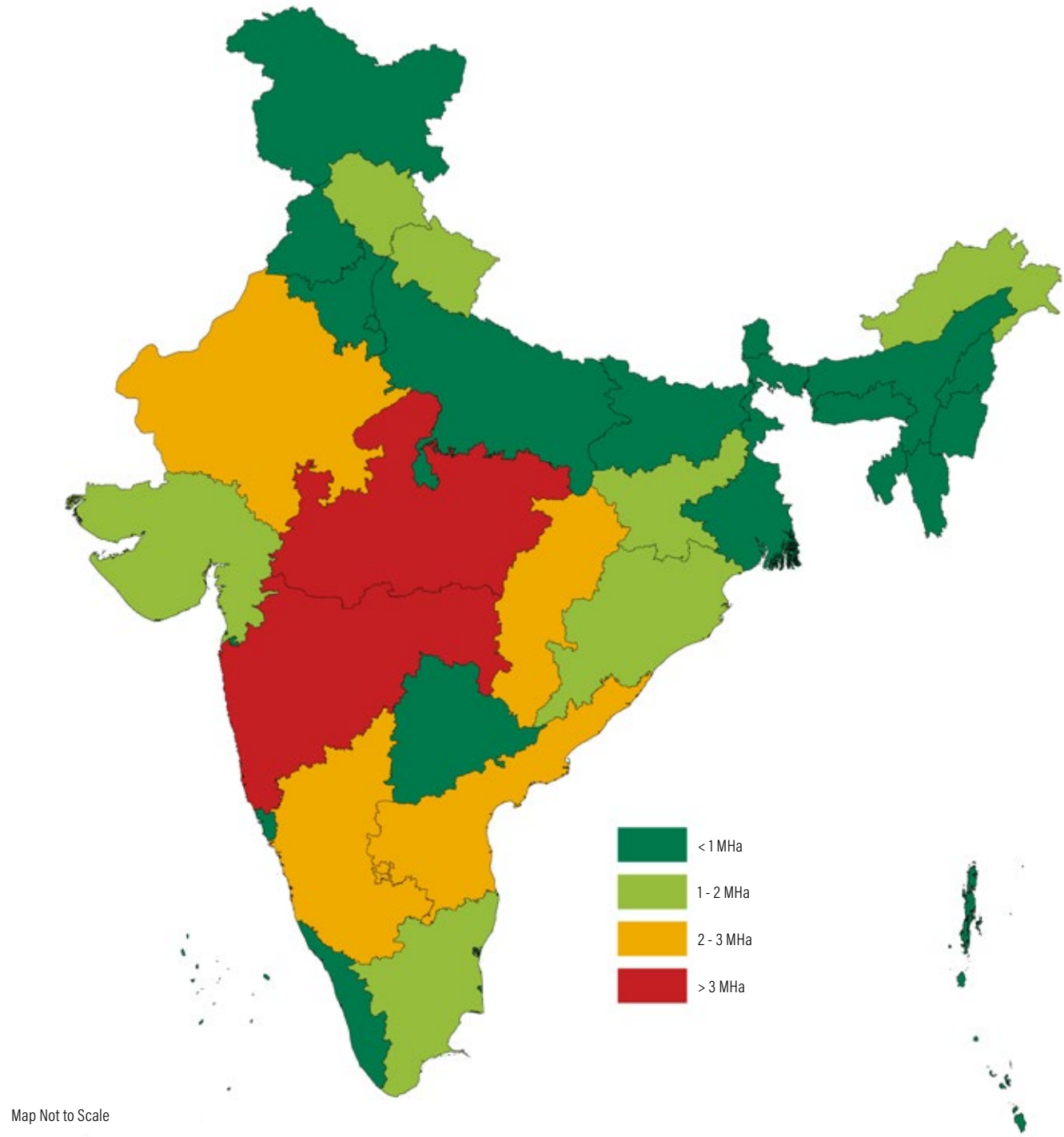
2. **Potential for Community Forest Resource Rights:** The Forest Rights Act 2006[6] provides scheduled tribes and other traditional forest dwellers with secure rights over forest lands on which they have traditionally depended. Based on analysis conducted by the BIPP-ISB, the atlas presents information on states' potential for CFRs. The layer is presented as Map 14. The atlas also shows the recognized CFR areas in the country (Agarwal and Saxena 2018)[7]. This information is presented in Map 15.

Map 13 | **Percentage of Recorded Forest Area under JFM**



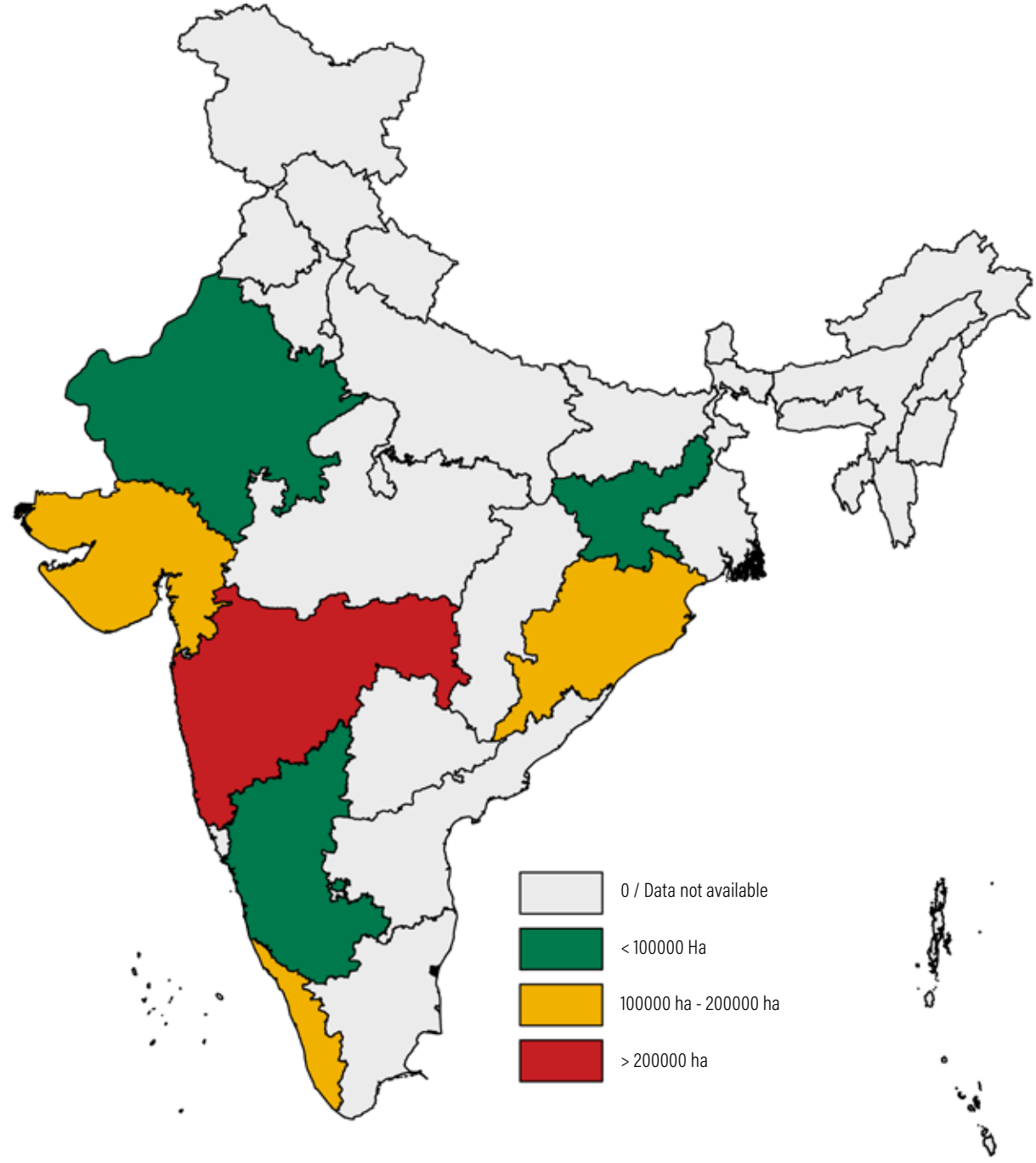
Map Not to Scale

Map 14 | Potential for CFR (in Mha)



Map Not to Scale

Map 15 | **Recognized CFR Areas (in ha)**

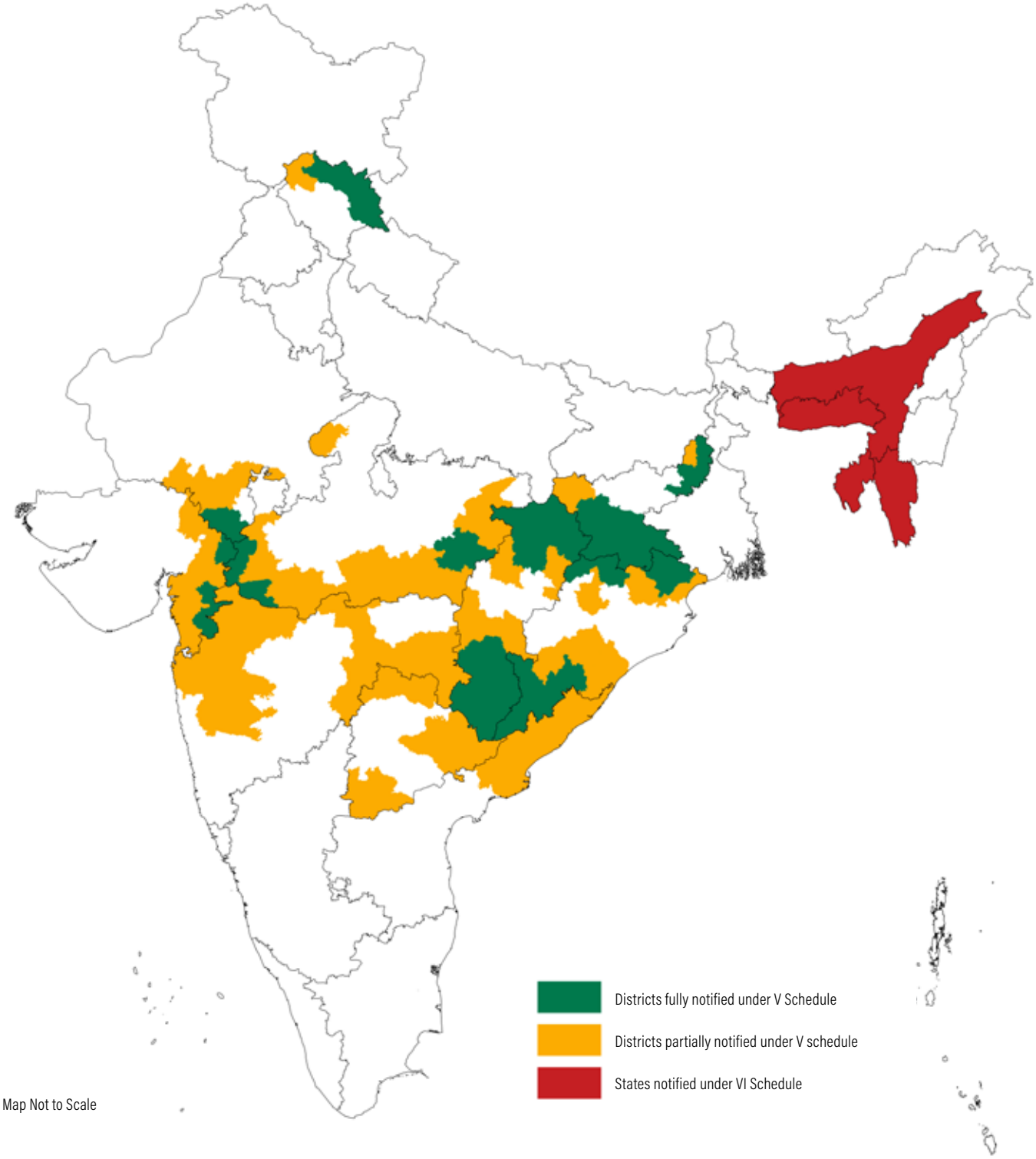


Map Not to Scale

3. **Fifth and Sixth Schedule Areas:** The Constitution of India provides alternate governance mechanisms for tribal dominated "scheduled areas" to protect tribal autonomy and culture as well as enable their economic empowerment. The Fifth Schedule applies to notified districts or parts of notified districts in ten states in India, namely, Andhra Pradesh, Chhattisgarh, Gujarat, Himachal Pradesh, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, and Telangana. In these Fifth Schedule areas, the Panchayat (Extension to Scheduled Areas) Act 1996 (PESA) decentralizes forest management and control, and provides communities ownership rights over minor forest produce (Ministry of Panchayati Raj 2018). Sixth Schedule areas comprise the states of Assam, Meghalaya, Tripura, and Mizoram. In these areas, the Constitution of India provides for the creation of

decentralized autonomous institutions that can, among other things, exert full control over forests and land-related decision-making (Constitution of India 1950). The Restoration Opportunities Atlas draws attention to the special tenurial arrangements in Scheduled Areas by identifying districts that have been partially and fully notified under the Fifth Schedule, as well as states that are covered under the Sixth Schedule. It should be noted that PESA is not applicable in Jammu and Kashmir due to its special status. The layer is presented in Map 16.

Map 16 | **Fifth and Sixth Schedule Areas**



FINANCE FOR RESTORATION

Preliminary estimates show that between 2011 and 2016, India allocated more than INR 102505 crores (16 billion US$)[8] to improving forest and tree cover, through public financing. The atlas presents information on finance for restoration in three layers[9].

Allocation of public finance to states excluding MGNREGS: This layer presents the combined allocations made to states between 2011 and 2015, through six major sources.

Budgetary allocation: This includes funds under the GIM, the Integrated Watershed Management Programme, and the National Afforestation Programme.

Compensatory Afforestation Fund: This includes funds allocated by the Compensatory Afforestation Management and Planning Authority (CAMPA), which is in charge of management of funds received for compensatory afforestation when forest lands are diverted for development activities.

Thirteenth Finance Commission: The Finance Commission is a constitutional body that determines states' share in tax revenue as well as the distribution of this share among the states. For the period 2011–2015, the Thirteenth Finance Commission distributed a sum of INR 5,000 crores among the states based on their forest cover.

NABARD: The National Bank for Agriculture and Rural Development (NABARD) is India's apex financial institution that supports various natural resource management and livelihood development projects. NABARD's projects that contribute to restoration include the Watershed Development Fund, the Tribal Development Fund, the Indo-German Watershed Development Programme, and the Umbrella Programme for Natural Resource Management.

Bilateral fund sources: Bilateral funds from developed countries include focus on activities for increasing forest and tree cover. Included here are projects sanctioned by the Japan International Cooperation Agency, the French Development Agency, and the KfW Development Bank with components on forestry, biodiversity, land degradation, agriculture, and watershed sectors.

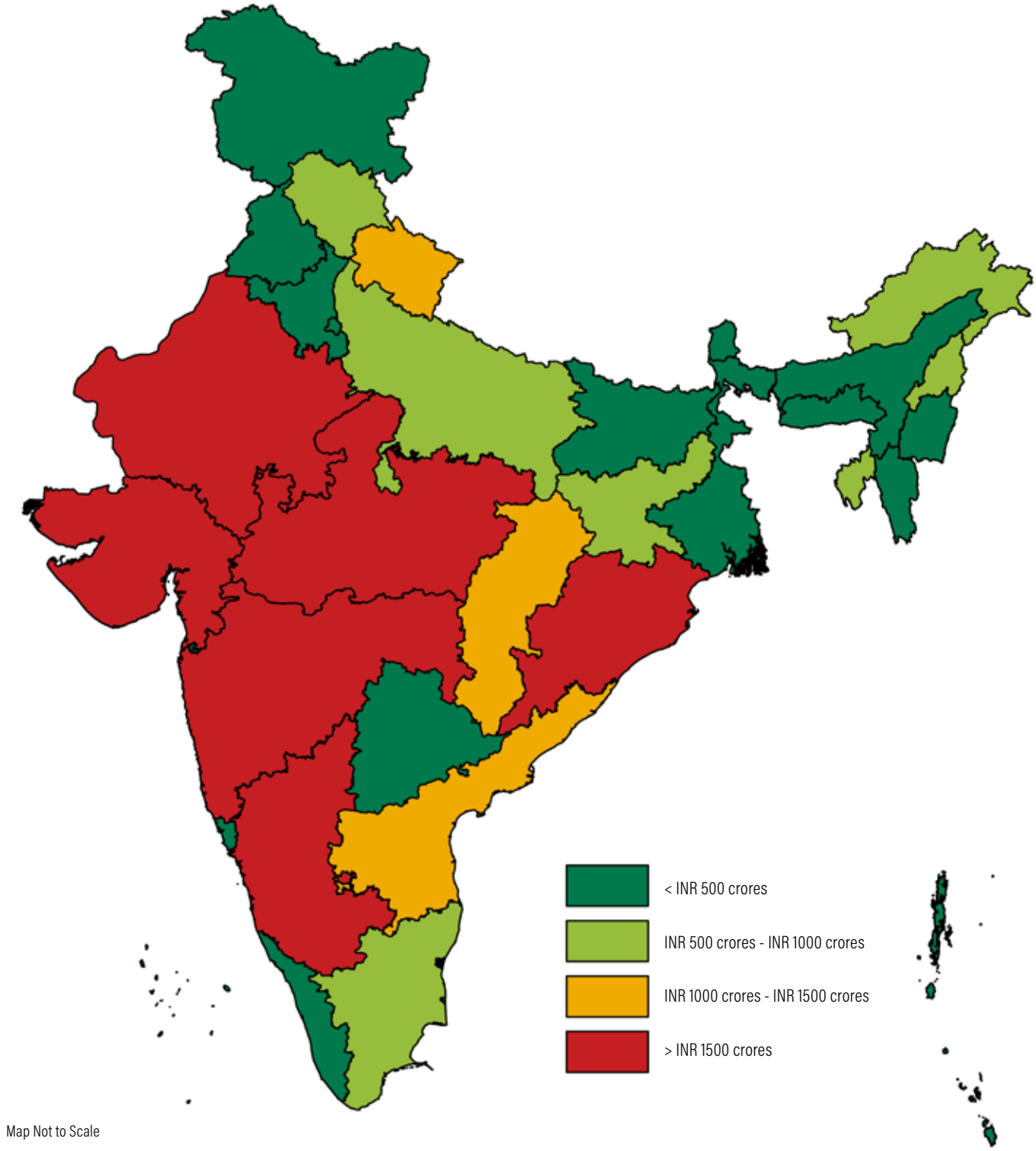
Multilateral fund sources: Multilateral funds with relevance to landscape restoration are from the Global Environment Facility and the World Bank.

The layer classifies states into four categories based on the allocation of public finance to states excluding Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). The layer is presented in Map 17.

Allocation under MGNREGS: MGNREGS accounts for more than 75 percent of public finance allocated for landscape restoration (MoRD 2017). Only restoration-related activities covered under MGNREGS were considered here. The layer classifies states into four categories, namely less than INR 2,000 crores, INR 2,000 crores to INR 4,000 crores, INR 4,000 crores to INR 6,000 crores, and more than INR 6,000 crores. The layer is presented in Map 18.

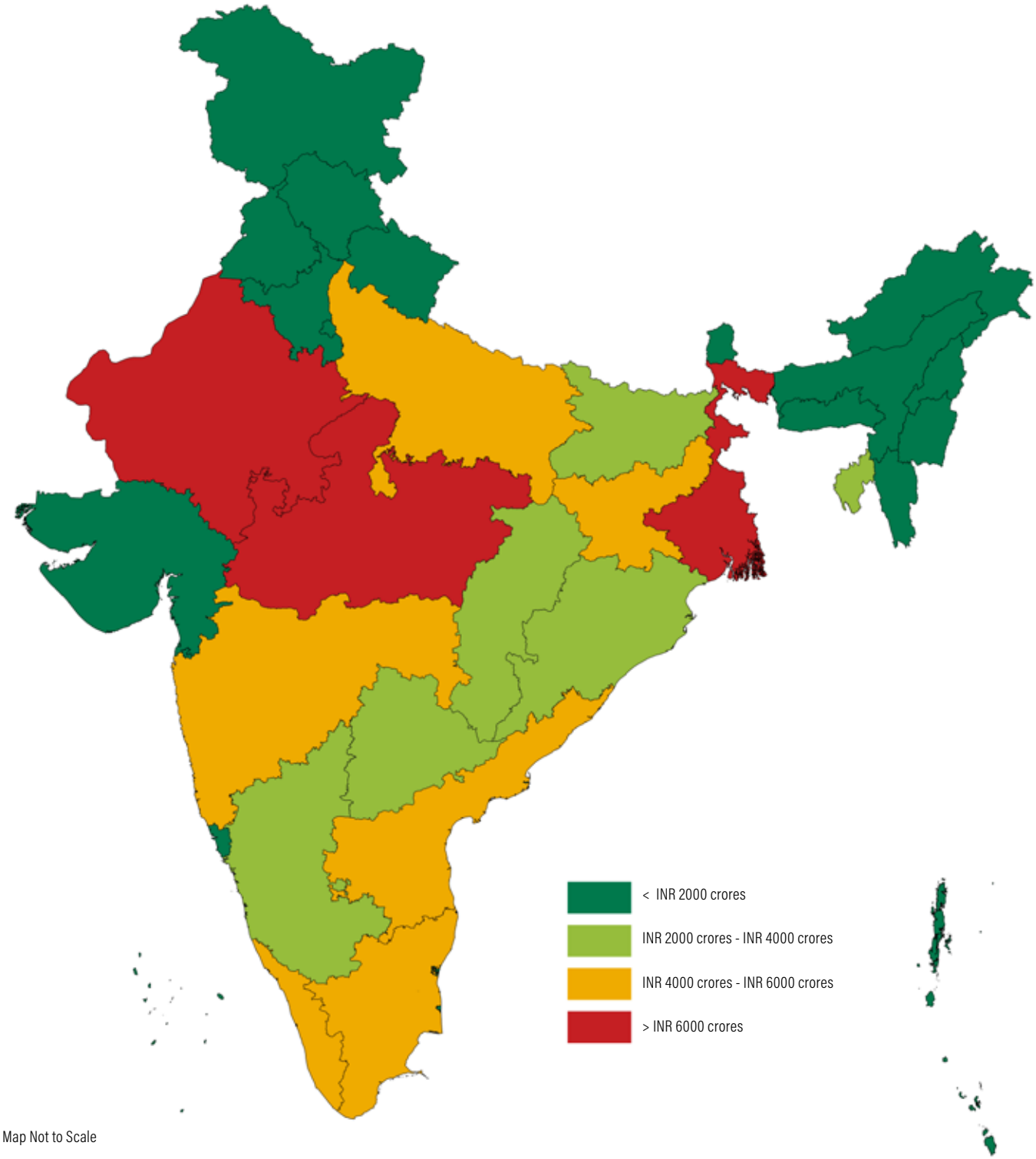
States' share in the CAF: This layer provides information on states' share in the CAF. When forest lands are diverted to developmental uses, project proponents are expected to pay toward compensatory afforestation and catchment area treatment, as well as compensation for the loss of ecosystem services. These payments have so far been collected in a centralized CAF, which today holds INR 66,000 crores (Parliament. Lok Sabha 2018). The recently enacted legislation provides that 80 percent of the CAF will be returned to the states for protection and restoration activities. The layer on states' share in the CAF classifies states into four categories, namely less than INR 2,500 crores, INR 2,500 crores to INR 5,000 crores, INR 5,000 crores to INR 7,500 crores, and more than INR 7,500 crores based on their contribution to the CAF. The layer is presented in Map 19.

Map 17 | **Allocation of Public Finance to States Excluding MGNREGS (in INR crores)**



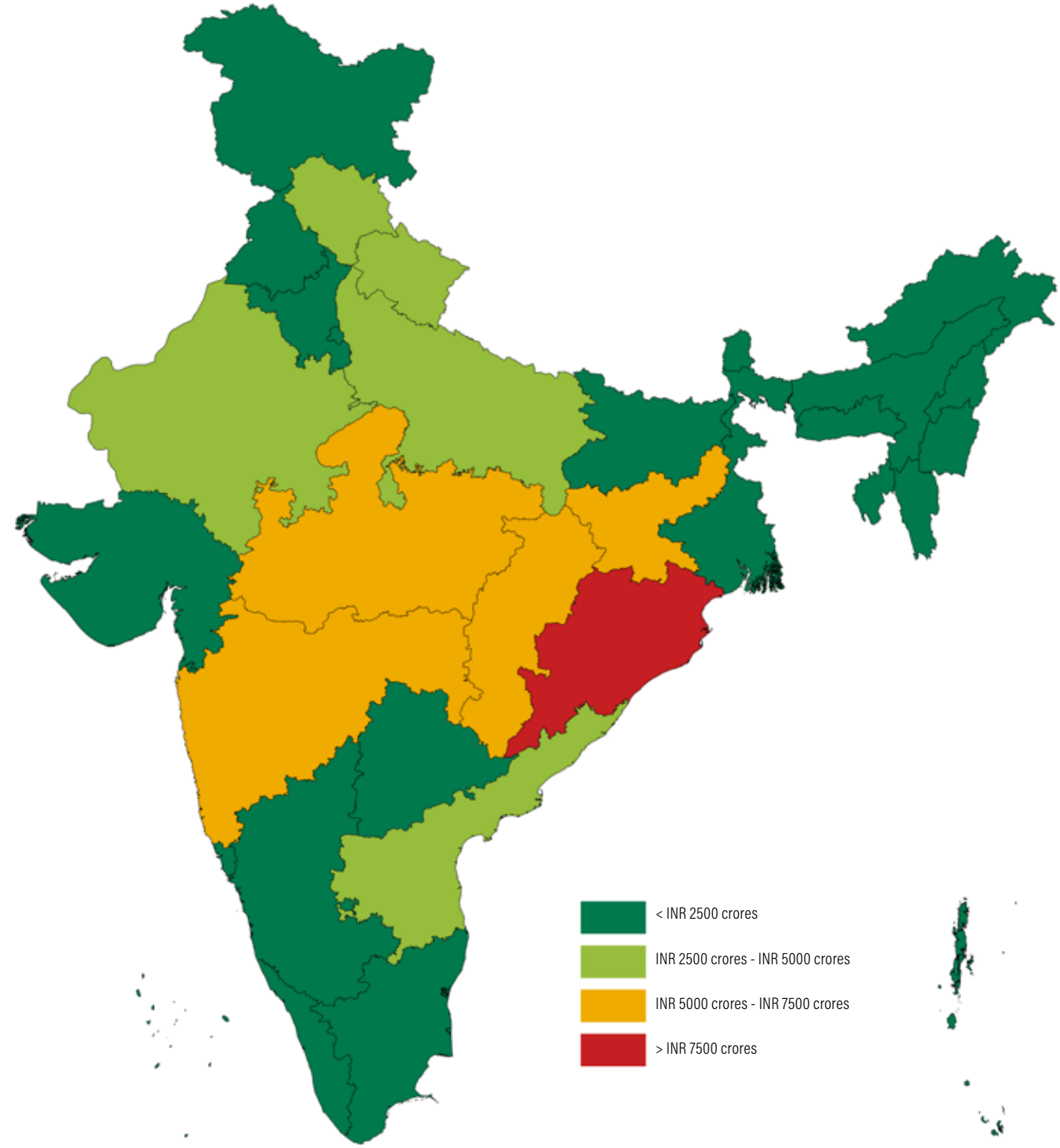
Map Not to Scale

Map 18 | Allocation under MGNREGS (in INR crores)



Map Not to Scale

Map 19 | States' Shares in the CAF (in INR crores)



Map Not to Scale

CONCLUSION

The Restoration Opportunities Atlas can support planning of improvement in forest and tree cover to achieve India's climate and development goals. India's NDC commits to sequester an 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 million ha of deforested and degraded lands by 2030 as well as the SDGs. The atlas brings together best available data and rigorous analysis for developing national and state-level pathways for achieving these commitments.

The restoration opportunities map of the atlas identifies areas for protection, wide-scale restoration, and mosaic restoration. On this basis, it estimates potential for increase in forest and tree cover and the associated carbon sequestration that can be achieved. The atlas supports planning for landscape restoration through the section on past and on-going initiatives, which identifies different types of interventions implemented in different states by various implementing actors. Further, it provides information on key enabling conditions that underpin the success of interventions, such as tenure and resource rights and finance for restoration. The atlas also provides details of risk factors to restoration.

Results from the atlas show that India can achieve the NDC and Bonn Challenge through forest protection and landscape restoration. The increase in forest and tree cover will not only sequester carbon but lead to a range of benefits, including biodiversity conservation; provisioning of fuelwood, fodder, and nontimber forest produce; and improvement of local livelihoods. The atlas provides a firm basis for setting a baseline for tracking progress toward these commitments. The atlas also has immense potential for performing granular analysis at sub-state levels with use of more accurate and higher resolution data.

DISCLAIMER

Appendix 1 | List of TWG Members Involved in Development of the Atlas

S. No	Name	Organization
1	Anushree Bhattacharjee	IUCN (India)
2	Areendran Gopala	WWF-India
3	Arpit Deomurari	WWF-India
4	BR Ramesh	French Institute of Pondicherry
5	Chiranjit Guha	Foundation for Ecological Security
6	Devashree Nayak	ICRAF
7	KK Singh	Vindhya Environment and Livelihood Trust
8	Partha Sarathi Roy	University of Hyderabad
9	P K Joshi	Jawaharlal Nehru University
10	Promode Kant	Institute of Green Economy
11	Pooja Gupta	Environics Trust
12	Prabhakar Rajagopalan	India Biodiversity Portal/ Strand LifeSciences
13	R Nagarajan	MS Swaminathan Research Foundation
14	Rachna Chandra	Gujarat Institute of Desert Ecology
15	Ravi Chellam	Metastring Foundation
16	Shamita Kumar	Bharati Vidyapeeth
17	Shashank Srinivasan	Technology for Wildlife
18	Sushil Saigal	The Nature Conservancy
19	Tejashree Joshi	Godrej Foundation

Appendix 2 | Other Spatial Layers Used in the Atlas

S. No	Spatial Layer	Description	Data source	Coverage	Resolution
1	Potential for increase in above-ground carbon sequestration	FSI data on above-ground carbon stock for forest classes in India.	FSI 2017	National	Not applicable
2	Past and ongoing initiatives	Information on various past and ongoing restoration initiatives in India	Various sources	National	Not applicable
3	Incidence of forest fire	Number of incidents of forest fires	Parliament. Lok Sabha 2014; Parliament. Lok Sabha 2016; Parliament. Lok Sabha 2017	National	Not applicable
4	Land and forest conflicts	Land conflict in forest areas	Land Conflict Watch 2018	National	Not applicable
5	Diversion of forest land	Data on forest lands diverted for non-forestry purposes	MoEFCC 2018	National	Not applicable
6	Percentage of recorded forest area to JFM	Presence of JFM in recorded forest area as a symbol of restoration interventions	MoEFCC 2011	National	Not applicable
7	Potential for recognition of CFR	Areas eligible for recognition of CFR	BIPP-ISB	National	Not applicable
8	Recognized CFR areas	Potential for CFR and extent to which CFR has been recognized in each state	Agarwal and Saxena 2018	National	Not applicable

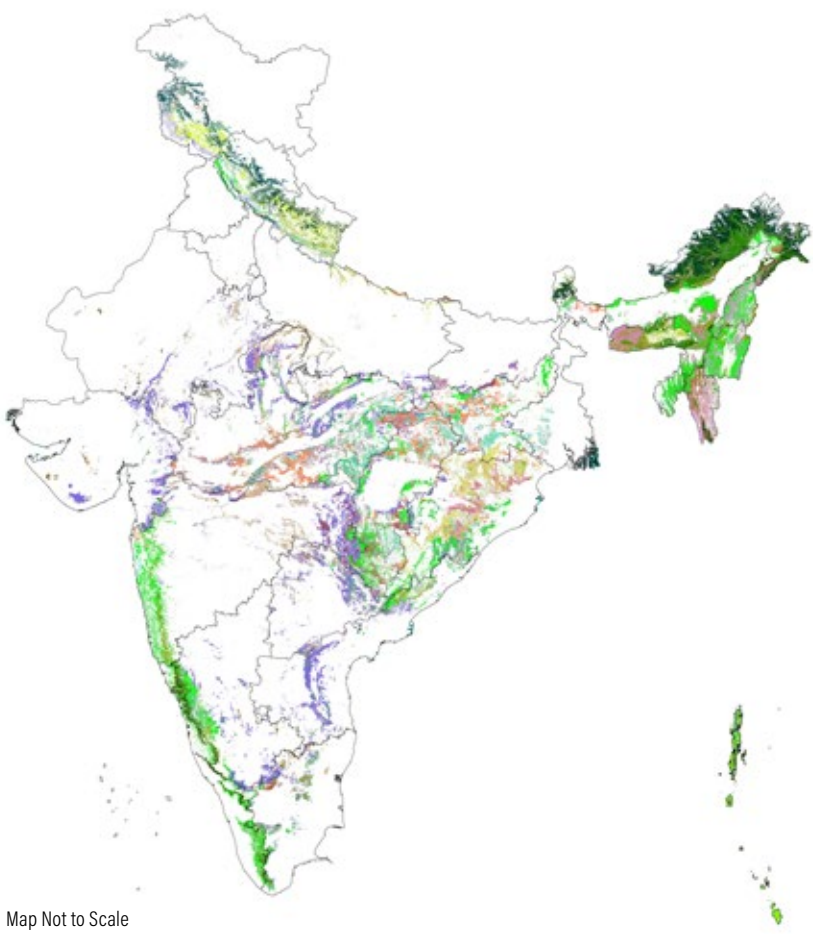
9	Fifth and Sixth scheduled areas	Schedule V and VI areas	GoI 2011	National	Not applicable
10	Allocation of public finance to states excluding MGNREGS	Allocation of public funds for restoration related activities	WRI India	National	Not applicable
11	Allocation under MGNREGS	Funds allocated to states under MGNREGS. This considers only restoration relate activities.	MoRD 2017	National	Not applicable
12	States' shares in CAF	Contribution of states to CAF	Parliament. Lok Sabha 2018	National	Not applicable

Appendix 3 | Land Use and Land Cover Layer Categories

1.	Forest
2.	Agriculture
3.	Agriculture plantations/ cash crops
4.	Mixed plantation/orchards
5.	Barren land
6.	Invasive species
7.	Rann of Kutch
8.	Swamp forest
9.	Grassland
10.	Non-forest
11.	Sand dunes
12.	Scrub areas
13.	Settlements
14.	Snow
15.	Water bodies
16.	Mangrove

Appendix 4 | Vegetation Classes and Biogeographic Zones

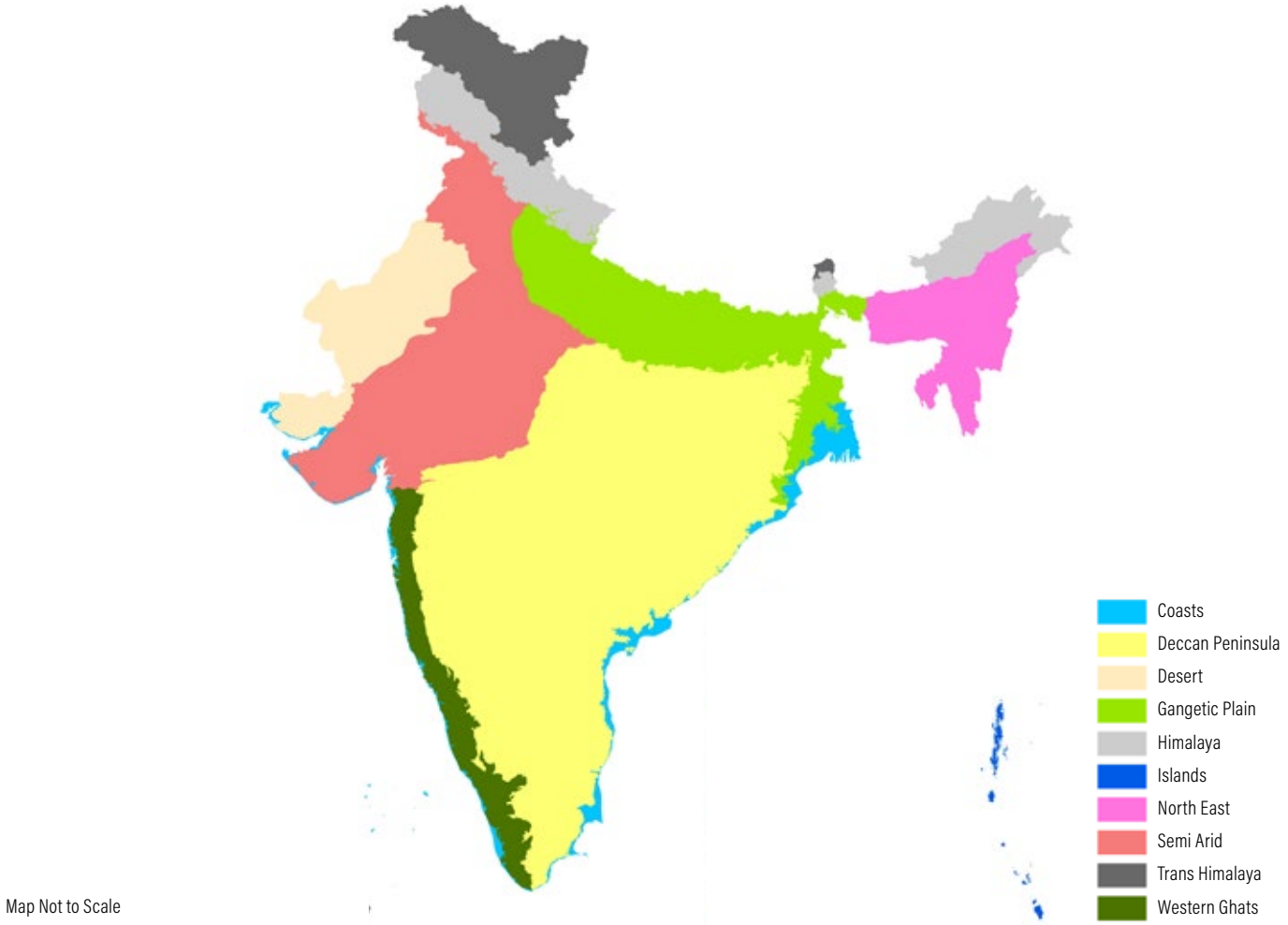
Map A1 | Vegetation Classes (Roy et al. 2015)



Map Not to Scale

- Abandoned Jhum
- Acacia
- Alnus
- Andaman evergree
- Anogeissus pendula
- Avicennia
- Bamboo
- Bamboo mixed
- Boswellia
- Cleistanthus
- Cryptomeria
- Cypress
- Degraded forest
- Deodar
- Dipterocarpus
- Dry deciduous
- Evergreen
- Fir
- Forest plantations
- Hardwickia
- Himalayan moist temperate
- Juniper
- Kans
- Littoral forest
- Lumnitzera
- Mangrove
- Mangrove scrub
- Moist deciduous
- Montane wet temperate
- Oak
- Padauk
- Phoenix
- Pine
- Pine mixed
- Ravine
- Red sanders
- Rhizophora
- Rhododendron
- Riverine
- Saffron
- Sal
- Sal mixed dry deciduous
- Sal mixed moist deciduous
- Secondary evergreen
- Semi-evergreen
- Sholas
- Sub alpine
- Sub-tropical broadleaved
- Sub-tropical dry evergreen
- Teak
- Teak mixed dry deciduous
- Teak mixed moist deciduous
- Temperate coniferous
- Thom forest
- Tree savannah
- Woodland
- Xylocarpus
- Ziziphus

Map A2 | Biogeographic Zones (Rodgers and Panwar 1988)



Map Not to Scale

Appendix 5 | Carbon Stock of Forest Types Used in the Analysis

Average Carbon Stock (Tonnes/ha)			
Forest Type	**OF (25% Mean Tree Cover)**	**MDF (55% Mean Tree Cover)**	**VDF (85% Mean Tree Cover)**
Tropical Wet Evergreen Forest	13.63	42.88	65.18
Tropical Semi Evergreen	9.44	29.77	57.41
Tropical Moist Deciduous	11.87	25.37	37.18
Tropical Dry Deciduous	12.79	59.00	62.48
Tropical Thorn Forest	4.91	11.75	13.30
Tropical Dry Evergreen	18.85	33.33	48.58
Subtropical Broadleaf Hill Forest	15.83	22.71	33.17
Sub-Tropical Pine	21.06	30.43	48.37
Subtropical Dry Evergreen	30.17	40.16	57.14
Montane Wet Temperate	9.53	26.09	41.14
Himalayan Moist Temperate Forest	26.59	55.68	72.98
Sub-Alpine Forests	30.75	41.57	70.74
Moist Alpine Scrub	17.03	28.03	50.19
Dry Alpine Shrub	28.83	31.87	81.44

ENDNOTES

1. The WADI model is a holistic approach to improving productivity of land and enhancing livelihoods of tribal communities. WADI envisages crops integrated with fruit trees suitable to that area along with forestry species in the periphery. WADI is being implemented by NABARD across India.
2. The FSI classification is based on IPCC's estimation of carbon stock in six major forest classes in Asia.
3. The state of Andhra Pradesh was divided into Telangana and Andhra Pradesh in 2014.
4. The portal is available at https://www.landconflictwatch.org/
5. In the North-East states, JFM is only applicable in Forest Development Agency plantations.
6. Enacted as the Scheduled Tribes and Other Traditional Forest Dwellers (recognition of forest rights) Act, 2006.
7. Figures updated to reflect revisions made by MoTA to data from Maharashtra in the monthly progress report - November, 2018.
8. The conversion factor used was INR 60.59 which was the average exchange rate of INR to US$ between 2011 and 2016. Large amounts of INR are expressed in crores. Quantitatively, INR 100 crore equals INR 1 billion.
9. The data used for layers in the Finance for Restoration section are based on research done by WRI India. The tables will be available in the platform.

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ABOUT WRI INDIA

WRI India is a research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

Our Challenge
Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Liveable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision
We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our Approach
COUNT IT
We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT
We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT
We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.

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