Mid-Term Evaluation of Forestry Plantations

Funded by the National Mission for Clean Ganga (NMCG)

प्रगतेः मूलं प्रकृतिः

Indian Institute of Forest Management

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Executive Summary

Under the NMCG funded Forestry Interventions for Ganga, more than Rs 100 crores was invested during 2016-17, 2017-18 and 2018-19 for taking up forestry plantations in the five Ganga basin states namely Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal. But how have these plantations fared and have they resulted in ecosystem restoration? This study addresses the above question by undertaking a comprehensive field evaluation of this intervention. This Report has been organized into 8 main chapters comprising of introduction, objectives, research design, state-wise findings and policy analysis along with references and supporting appendices. In this study IIFM has attempted to delight the customer by delivering beyond the agreed scope of this study by assessing 20% of the investment against the promised 10% to make the evaluation more representative, organizing consultations with all the five state forest departments to discuss all the suggestions threadbare to bring about a shared understanding of the field issues and by undertaking a literature review of restoration best practices to suggest improvements in the design of the programme in the next phase.

Monitoring and evaluation of the forestry interventions needs to go beyond the single parameter of survival percentage and delve deeper by asking whether the site selected was suitable for tree planting? Whether the species planted are native and suited to the ecosystem? Is the growth of the plants adequate? and finally will they survive beyond the project period and establish into plantations? Only when a plantation performs well on all these parameters it can be termed as successful. The objective of this mid-term evaluation study was to assess the performance of the forestry plantations and revolves around three key evaluation questions namely what is the status of survival and growth, what are the best practices and common pitfalls and the lessons for the next phase. In terms of the evaluation framework we used the three dimensions of relevance, effectiveness and sustainability covering the five variables of site suitability, species selection, growth, survival and sustainability.

A two stage sampling design was adopted. In the first stage, the plantation sites were selected and in the second stage within a site the plants were sampled. Stratified sampling was used taking state and landscape (natural, agriculture and urban) as the strata. Larger projects with higher investments were prioritized. A sampling intensity of 20% of the investment made during 2016-17, 2017-18 and 2018-19 was adopted. In the five states, a total of 95 plantation sites were evaluated with 59 in the natural landscape, 30 in urban landscape and 6 in agriculture landscape. Within a project site, area-based sampling was carried out till the accumulation curve of the survival percentage saturated. Mixed methods were used involving

quantitative and qualitative tools such as literature review, field observation, plantation enumeration, key informant interviews, consultation with officials and use of google earth images. The main difficulties faced by the project were COVID wave disruptions during 2021 and 2022 and heavy and late monsoons during 2021.

The afforestation context across the five Ganga bearing states is very different due to variation in geography, climate, availability of forest land, grazing pressure, other biotic threats etc. The mountain terrain of Uttarakhand is characterized by remoteness, fragility, forest fires, landslides, shallow soils, limited growing period, grazing pressure, weed infestation and summer moisture stress. In Uttar Pradesh, the riverscape is subject to regular floods, inundation, frost and hot summers. Feral cattle and Nilgai are another serious threat to the survival of the plantations. Bihar has shortage of forest land to take up afforestation and high population density along the roadsides where avenue plantations were taken up. It is also affected by severe water logging and floods during the monsoons. In West Bengal most of the afforestation was carried out in the south western part which lies on the edge of the Chota Nagpur plateau and is characterized by shallow lateritic soils, water scarcity and is inhabited by tribals communities. Hence, due to this diversity of restoration contexts, it may not be wise to compare the plantation performance across states.

The overall survival percentage and growth of the plants in all the five states was found to be satisfactory. The survival percentage at the state level varied between 60-84% while the height attained by the plants ranged between 1.5 to 6.0 meters in four years. We came across several good practices and plantation outcomes in the five states. In Uttarakhand state, oak and Devdar species were prioritized, overall plant survival was good, horticulture trees planted in homestead performed well and soil and moisture conservation measures were effective. The urban avenue plantations in Uttar Pradesh showed excellent surival and growth. In Bihar and Jharkhand tall seedlings (2 meters height) of native trees were planted, in water logged areas mound planting of Arjun and Jamun was done and overall robust growth of the plants was observed. The scale of reforestation at Mehdipur in Jharkhand resulted in the creation of a biodiversity haven along the banks of the river Ganga and deserves special mention. The native tree species planted in West Bengal showed good survival and growth due to excellent site and species selection, active involvment of the tribal community, effective soil and moisture conservation works and was backed by meticulous record keeping as well. Urban landscape plantations in all the states using tree guards showed very good survival and growth. In terms of people's participation, Jharkhand and West Bengal showed good results. In Jharkhand the support of Ganga Prahari's was taken to gain entry into the village and economic incentives were provided such as wage employment, inter-cropping of pulses, cut and carry of fodder etc. to win people's support. While in West Bengal

the existing Forest Protection Committees were partnered with for protection of the plantations.

It is the plantations in the natural landscape were improvements are needed in select locations. The common pitfalls identified were selection of unsuitable sites, planting exotic species, planting small-sized plants, damage to plants by cattle and wildlife, weed infestation, lack of community participation and weak record keeping. Selection of unsuitable sites such as natural grasslands, in dense forest cover, active landslide zones, river bank erosion areas etc. for afforestation. Selecting sites with high vulnerabilities such as cattle grazing, browsing by wild herbivores, weed infestation etc. without adequate mitigation and adaptation measures. In terms of species choice, exotic species such as *Prosopis juliflora* (vilayati babool) in Uttar Pradesh, Akashmoni (*Acacia auriculiformis*) in West Bengal, and others, were planted in natural areas as these are hardy and show good survival and growth. Small sized seedlings (less than 0.30 m height) were observed in the natural landscape of Uttarakhand and Uttar Pradesh and though surviving did not show satisfactory growth. Cattle trench, stone wall and barbed wire fencing were not able to protect the plantations adequately from cattle and wildlife in many locations. Few states had weak record keeping as well which hampered monitoring and evaluation. The linear plantations along roads, railway lines etc., with bamboo tree guards were not documented segment-wise in most of the states for ease in monitoring and evaluation. The watch and ward was impacted by long delays in release of wages to the plantation chowkidars in all the states. Across the landscape other than Jharkhand and West Bengal there was lack of people's participation and as a result the forestry plantations lacked community ownership. Plantation targets should be assigned based on a field assessment in consultation with the forest divisions and only deforested sites selected carefully for restoration. In the states of Uttar Pradesh, Bihar, Jharkhand and West Bengal, the landuse adjacent to the Ganga river and its tributaries is smallholder farming and is human dominated. There is a need to promote economic tree plantations (including bamboo) in this agriculture landscape by implementing the plantations models AL/P/01 and AL/P/02 on large scale. Even in Uttarakhand the AL/H/01 model is showing good results and needs to be scaled up. Larger investments are needed to scale up these plantations in the agricultural landscape as they are beneficial for nature and people both.

We then collated the global best practices on ecorestoration and the experience gained in the first phase of this programme, and using this lens analyzed the policy design of this programme as prescribed in the Forest Research Institute DPR. We suggest that the threats posed by the drivers of degradation such as grazing, fire, weeds etc. need to be factored in the plantation plan before afforestation is initiated. The whole range of ecological restoration approaches, namely, natural, assisted and artificial need to be made permissible based on

the status of the ecosystem, i.e., whether it is degraded, damaged or destroyed. Instead of the uniform artificial (reconstructive) regeneration approach. Exotics should be avoided and native species preferred. Non-forest ecosystems such as grasslands, savannahs, wetlands that have intrinsic ecosystem values and benefit local communities need to be protected from tree plantations. Mandatory planting of grasses and sedges in the riverscape to be discontinued as these regenerate naturally. Also, the mandatory medicinal plants component to be discontinued as it is not directly contributing either to Nirmal or Aviral Ganga. In the plantation sites in the natural landscape, soil and moisture conservation works such as creation of water bodies and soil and water conservation structures should be dove tailed for improving soil moisture conditions. Strengthening the digital record keeping and spatial database of the plantations is also needed. A special GIS database may be established in NMCG to keep a record of these investments in natural capital which will enable effective monitoring and evaluation in future.

Overall the evaluaton found that the NMCG funded forestry plantations are performing well. By avoiding the pitfalls, scaling up the good practices and adopting policy changes in the programme design as discussed above, the next phase of the programme can show still better results.

Abbreviations

AL	Agricultural Landscape
APO	Annual Plan of Operation
DAP	Di-ammonium Phosphate
DPR	Detailed Project Report
ETF	Eco-Task Force
FPC	Forest Protection Committee in West Bengal
FRI	Forest Research Institute, Dehradun
IAS	Invasive Alien Species
IFAD	International Fund for Agriculture Development
IIFM	Indian Institute of Forest Management
NBS	Nature Based Solution
NL	Natural Landscape
NMCG	National Mission for Clean Ganga
QGS	Quick Growing Species Plantation Model of West Bengal
QPM	Quality Planting Material
RCC	Reinforced Cement Concrete
SC	Soil Conservation
UL	Urban Landscape
UP	Uttar Pradesh
URF	Urban Recreation Forestry Division, West Bengal Forest Department
WB	West Bengal

Definitions

We provide a few standard scientific definitions that are often used interchangeably in policy and practice or misunderstood, leading to misinterpretation.[1, 2]

Afforestation is the establishment of a forest or a stand of trees in an area where there was no previous tree cover

Ecological restoration (or ecorestoration) is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed

Forest expansion implies the development of forests where they did not historically occur

Forest regeneration is defined as the renewal of a forest crop by natural or artificial means

Reforestation is planting trees on deforested lands

References:

Clewell, A., Aronson, J., & Winterhalder, K. (2004). The SER international primer on ecological restoration.

Veldman, J. W., Overbeck, G. E., Negreiros, D., Mahy, G., Le Stradic, S., Fernandes, G. W., ... & Bond, W. J. (2015). Where tree planting and forest expansion are bad for biodiversity and ecosystem services. *BioScience*, 65(10), 1011-1018.

[1] Veldman *et al.* (2015)

[2] Clewell *et al.* (2004)

Chapter 1
Introduction

1.1 Background

The NMCG wrote to IIFM on 3rd December, 2020 for taking up a mid-term evaluation of plantation projects funded by it during the five years from 2016-17 to 2020-21 in the five states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal. The Administrative Approval and Expenditure Sanction (AA&ES) statements for these five years to these five states was also shared with IIFM. Accordingly, a project proposal was prepared by IIFM and finalized based on mutual consultations. It was decided that IIFM would evaluate the plantations taken up during the three years 2016-17, 2017-18 and 2018-19 in the five states. The proposal prepared by IIFM was presented in the 33rd Empowered Committee of the NMCG held on 20th Jan, 2021 and accorded approval. The Administrative Approval and Expenditure Sanction (AA&ES) for the project was conveyed on 17th Feb, 2021 approving a cost of Rs 111.59 lakh with a duration of 10 months i.e. up to 31st Dec, 2021. Subsequently, due to the COVID pandemic disrupting field work a no-cost extension was granted by NMCG up to 30th April, 2022 vide letter dated 3rd December 2021 and then upto 30th June, 2022 vide letter dated 2022.

1.2 Forest landscape restoration

There is a global drive to restore degraded ecosystems so that they can again harbour biodiversity, sequester carbon and provide the full range of ecosystem services.[3] One of the approaches in this direction is the forest landscape restoration (FLR) which aims to bring back functionality and productivity to deforested lands while contributing to social and economic wellbeing.[4] In 2011, as a part of the Global Restoration Initiative (Bonn Challenge), 47 governments committed to bringing 150 million hectares of deforested and degraded land into restoration using the FLR approach by 2020 and 350 million hectares by 2030. The government of India made a Bonn Challenge pledge to bring under restoration 13 million hectares of degraded land by 2020 and an additional 8 million hectares by 2030. Reportedly, it has made a steady progress towards this pledge and by 2018 had already brought an area of 9.8 million hectares under restoration since 2011.[5] Primary approach to FLR in India has been afforestation which is funded through several flagship programmes such as the National

[3] IPBES 2018
[4] McLain et al. 2021
[5] Borah et al. 2018

Afforestation Programme (NAP), National Mission for a Green India (GIM), National Green Highways Mission, National Mission for Clean Ganga, Compensatory Afforestation, Nagar Van Yojana and others. The focus of this report is the National Mission for Clean Ganga (NMCG) which has been funding afforestation in the five Ganga basin states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal since 2016-17. The rejuvenation of the river Ganga is one of the important national agenda of the Government of India. A comprehensive approach towards Ganga Rejuvenation under the "Namami Gange" has been initiated by Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation. The vision is to restore the wholesomeness of the River by ensuring *Aviral* and *Nirmal Dhara*, and maintaining its geo-hydrological and ecological integrity. This approach differentiates this from earlier attempts. Integrated River Basin Management (IRBM) approach is followed with multi sectoral and multi-agency interventions such as (i) pollution abatement (Nirmal Ganga), (ii) improving ecology and flow (Aviral Ganga), (iii) strengthen people river connect (Jan Ganga) and (iv) facilitate diversified research, scientific mapping, studies and evidence based policy formulation (Gyan Ganga).[6]

1.3 The restoration context of the Ganga riverscape

Active restoration of the headwaters of the Ganga, its tributaries and their catchments will directly impact the river water quality and quantity. Land availability for reforestation is the biggest challenge in restoring the river Ganga, it is only in Uttarakhand that the Ganga flows through forests. In all the other states the riverscape has undergone a major transformation by humans. The landuse adjacent to the riverscape is smallholder farming and is human dominated. The non-availability of public lands on-scale in the Ganga riverscape is one of the biggest constraints in restoring the river Ganga. The afforestation context across the Ganga bearing states is very different due to variation in geography, climate, land tenure, population density, biotic pressure etc. Uttarakhand and West Bengal have extensive natural forest areas where the grazing pressure is less compared to that in Bihar and Uttar Pradesh. In Bihar there is a lack of natural forest area to take up plantations and hence most of the investments were made in urban landscape. While in Uttar Pradesh due to heavy grazing pressure from feral cattle and Nilgai many of the plantations have to be protected using barbed wire. Hence, it may not be wise to compare the performance across states as the restoration context is very different.

[6] NMCG AR 2020-21

1.4 Rationale of forestry interventions for rejuvenating the Ganga

For several centuries humans across the world have modified the riverscapes to enhance their function as drainage, navigation, energy generation, agriculture production and settlement in the floodplain areas.[7] The Sustainable Development Goals 14 and 15 (Life on Land and Life below Water) explicitly aim at enhancing global ecological conditions of river landscapes. Reforestation is a Nature Based Solutions (NBS) to restore the riverine ecosystem and sustain the quality and quantity of the river flow. NBS is defined by IUCN as "Actions to protect, manage and restore natural or modified ecosystems, which address societal challenges, effectively and adaptively, providing human wellbeing and biodiversity benefits." Investment in the wider river basin is increasingly seen as a way to address urban water challenges such as floods, shortages in supplies or degradation of water quality. NBS are seen as beneficial over purely technical solutions in that they minimize negative-side effects and instead create co-benefits for people and nature today and in the future.[8]

One of the major initiatives for Ganga rejuvenation is 'forestry interventions' to enhance the productivity and diversity of the forests in head water areas, and all along the river and its tributaries. To achieve this, NMCG assigned Forest Research Institute, Dehradun (FRI), Dehradun to prepare a Detailed Plan Report (DPR). Accordingly, FRI prepared a Detailed Project Report titled, "Forestry Interventions for Ganga" in 2016. This DPR was prepared to facilitate the major goals of accomplishing *nirmal dhara* (unpolluted flow) and *aviral dhara* (continuous flow) by taking up plantation activities in natural, agricultural and urban landscapes. This DPR proposes afforestation in an area of 1,34,106 hectares in the Ganga riverbank states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal at an estimated cost of Rs. 2293.73 Crores. The Detailed Project Report (DPR) is conceptually based on afforestation of surrounding areas of the river considering the fact that the forests play a vital role in maintaining the hydrology and environmental sustainability of the river and its course. The rationale is based on the premise that forests and trees through their foliage, bark and leaf litter decrease the speed of the water dispersion and favour slow but greater infiltration of rainwater to ensure smooth functioning of the hydrological cycle. Moreover, presence of healthy forests along the river will provide self-cleaning ability to the river. Thus afforestation and augmentation of existing forests along with river Ganga will strengthen the riparian ecosystem. It will also lead to improved biodiversity, increased carbon sequestration, better adaptability to climate change and reduced instances of flash floods.

[7] Albert et al. 2021
[8] Albert et al. 2021

1.5 Plantation models

The plantation design and the treatment models prescribed in the FRI DPR were selected after exhaustive review, consultation with the five participating states and by applying geo-spatial modelling in the riverscape. These plantations were taken up within 10 km of the main Ganga river bank and 5 km of its tributaries. In this DPR for each of the five states, plantation models have been designed for the natural, agricultural and urban landscapes. Each of these plantation models specify the number of trees, shrubs, bamboo, medicinal plants, grasses and sedges that need to be planted. It provides for 43 numbers of models under four major heads viz. Natural landscape-32, Agriculture landscape-3, Urban landscape-5, and Conservation intervention-3. The summary of these 43 plantation models is provided in Annexure 10.3. The report also provides a list of suggested species for plantation under these models.

1.6 References

Albert, C., Hack, J., Schmidt, S., & Schröter, B. (2021). Planning and governing nature-based solutions in river landscapes: Concepts, cases, and insights. *Ambio*, 50(8), 1405-1413.

Borah, B., Bhattacharjee, A., and Ishwar, N.M. (2018). Bonn Challenge and India: Progress on restoration efforts across states and landscapes. New Delhi, India: IUCN and MoEFCC, Government of India, New Delhi.

IPBES (2018). The IPBES assessment report on land degradation and restoration. Montanarella, L., R. Sholes, and A. Brainich (Eds.). Secretariat of the Intergovernmental Science – Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany. pp. 744.

McLain, R., Lawry, S., Guariguata, M. R., & Reed, J. (2021). Toward a tenure-responsive approach to forest landscape restoration: A proposed tenure diagnostic for assessing restoration opportunities. *Land Use Policy*, 104, 103748.

NMCG AR (2020-21). Annual Report 2020-2021. National Mission for Clean Ganga (Registered Society under Societies Registration Act, 1860) Department of Water Resources, River Development & Ganga Rejuvenation Ministry of Jal Shakti, Government of India.

https://nmcg.nic.in/writereaddata/fileupload/19_NMCG%20Annual%20Report%202020-21English.pdf

Chapter 2

Objectives and Scope

Evaluation is a rigorous and independent assessment of project activities to determine the extent to which they are achieving stated objectives. The key distinction between evaluation and monitoring is that evaluations are done independently and are also more rigorous in their procedures, design and methodology, and generally involve more extensive analysis. Evaluation of plantations need to cover aspects of site suitability, species selection, survival, growth and future sustainability.

2.1 Objectives

The objective of an evaluation is to provide information that can help inform decisions, improve performance and achieve planned results. The objective of the present evaluation study is to answer the following key questions namely:

1. What is the actual extent of the plantations?
2. What is the status of survival and growth?
3. What are the best practices and common pitfalls?
4. How can we improve future plantations?

> In addition to reporting on "what" the performance was, evaluations should strive for a deeper understanding of "why" the performance was as it was.
>
> This helps in consolidation of the lessons learnt and provides a direction for the future strategy.
>
> - *IFAD Evaluation Manual (2009)*

We assessed not only the outputs and outcomes of the programme, but also critically analyzed the programme design, decision making and implementation process. Evaluators need to answer the 'why' question. So for plantations that are excellent, the evaluation probed the reasons for the success, and for plantations that performed poorly, the reasons for the failure were noted. So that in the phase, corrective action can be taken to upscale the success stories and prevent the failures from repeating.

2.2 Scope

What the evaluation covered

- Plantations 2-year old and above, as those that are younger are yet to establish, and evaluating them would have resulted in a bias. Hence the evaluation covered 2016-17, 2017-18, 2018-19 plantation projects.
- Five states (Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal)

What the evaluation did not cover

- Non-plantation projects
- Plantations less than 2-year old, as these plantations are yet to establish, and it would be pre-mature to evaluate them.
- Efficiency of the projects as it would take on the shape of a financial audit which is done by auditing agencies
- Impact of the project, as it is premature to measure it as plantations are only a few years old, however the probably impact of the works was discussed.

Chapter 3

Sampling Design and Methods

3.1 Evaluation framework

The IFAD evaluation framework elucidates five dimensions that need to be covered namely relevance, effectiveness, impact, efficiency and sustainability (IFAD evaluation manual 2009).

- **Relevance** concerns the extent to which a development initiative and its intended outputs or outcomes are consistent with the needs of the environment and the intended beneficiaries. Relevance also considers the extent to which the plantation activity is suited to the environment and the intended beneficiaries. In applying the criterion of relevance, the evaluation explored the extent to which the planning, design and implementation took into account the local context in terms of needs of the local community and the environment. Two variables namely site suitability and species selection were measured.
- **Effectiveness** is a measure of the extent to which the initiative's intended results have been achieved. Evaluating effectiveness involves an assessment of cause and effect that is, attributing observed changes to project activities and outputs. While assessing the effectiveness of plantations, the two variables - growth and survival were measured.
- **Impact** measures changes in human development and people's well-being that are brought about by development initiatives, directly or indirectly. At times, evaluating impact faces challenges: Confirming whether benefits to beneficiaries can be directly attributed to the intervention can be difficult, especially since there are several ongoing interventions often with overlapping objectives. As the plantations are only a few years old, it is too early to measure their impact either on local livelihoods or the environment.
- **Efficiency** includes a measure of how economically inputs (funds, expertise, time, etc.) are converted into results. An analysis of budget use and compliance is also important in order to assess the efficiency dimension. Measuring efficiency will need assessment of financial aspects and would take the form of financial audit and hence was not attempted.
- **Sustainability** is the likely continuation of net benefits from an intervention beyond the phase of funding support. It includes an assessment of the likelihood that the results will be resilient to risks beyond the project's life. While assessing sustainability the prospects of future survival of the plants was assessed based on risks like droughts, grazing, fire etc.

Hence, of these five evaluation criteria, the present evaluation covered the three dimensions of relevance, effectiveness and sustainability by measuring the five variables namely site suitability, species selection, growth, survival and sustainability.

3.2 Sampling design

During field evaluation, a two stage sampling design was adopted. In the first stage the plantation projects were selected and in the second stage within a project site the plants were selected.

3.2.1 Sampling projects

The NMCG forestry plantation projects to be evaluated span across three years namely 2016-17, 2017-18 and 2018-19 and are spread across five states namely Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal. A total investment of Rs 197.64 crore was made in these three years based on the Administrative Approval and Financial Sanction (AA&ES) letters of NMCG Table 3.1).

Table 3.1: Investment as per NMCG sanction letters

Rs in lakhs

State	2016-17	2017-18	2018-19	Total
Uttarakhand	1,593	1,957	2,849	6,399
Uttar Pradesh	808	913	2,186	3,907
Bihar	604	1,798	2,069	4,471
Jharkhand	799	544	670	2,013
West Bengal	1,116	848	1,009	2,973
Total	**4,920**	**6,060**	**8,784**	**19,764**

The data compiled from the states showed that works to the tune of Rs 102.41 crores were taken up in this period owing to seasonality of afforestation and activities carried forward to the next year (Table 3.2).

Table 3.2: Investment as per APOs of state forest departments

Rs in lakhs

State	2016-17	2017-18	2018-19	Total
Uttarakhand	78	1,026	1,704	2,809
Uttar Pradesh	580	512	745	1,837
Bihar	754	1,740	1,186	3,681
Jharkhand		394	368	762
West Bengal	53	414	686	1,152
Total	**1,465**	**4,086**	**4,689**	**10,241**

In the proposal, IIFM had committed to taking up 10% of the projects for evaluation based on investment i.e. Rs 19.7 crores out of the total 197 crores. Typically, 10% sampling intensity is the standard practice in evaluations (IIFM 2016). Hence, in order to harmonize the physical scope of the evaluation work, we evaluated 20% of the projects based on investment which amounts to Rs 20.46 crore. This ensured that the physical scope remained the same, and also resulted in a more comprehensive evaluation. Hence, the evaluation was done with a sampling intensity of 20% of the financial investment against the initially planned 10%.

The nature of the projects is diverse covering natural, agricultural and urban landscapes. Also, the physical extent of the plantations had diverse units with block plantations in ha, avenue plantations in running km and some in terms of number of plants planted. So financial investment was used as the unifying measure to assess the extent of the plantations. The evaluation strategy adopted was a "deep dive" instead of "spreading thin" to assess both the "what" and the "why". Stratified sampling was applied taking state and landscape (natural, agriculture and urban) as the strata. Plantation projects were sampled within a stratum purposively by prioritizing larger projects with higher investments (Figure 3.1). Within a project site, area-based sampling was carried out till the accumulation curve saturated.

Table 3.3: Field evaluation in terms of investment made

Rs in crores

State	Total investment	Total investment to be evaluated (20%)	Actual investment evaluated	% evaluated
Uttarakhand	28.09	5.61	5.78	103%
Uttar Pradesh	18.37	3.67	3.69	101%
Bihar	36.81	7.36	7.56	103%
Jharkhand	7.62	1.52	2.36	155%
West Bengal	11.52	2.3	2.41	105%
Total	**102.41**	**20.46**	**21.8**	**107%**

Table 3.4: Field evaluation in terms of number of sites evaluated

State	Natural	Urban	Agricultural	Total
Uttarakhand	47	3	6	56
Uttar Pradesh	6	14	0	20
Bihar	1	9	0	10
Jharkhand	1	2	0	3
West Bengal	4	2	0	6
Total	**59**	**30**	**6**	**95**

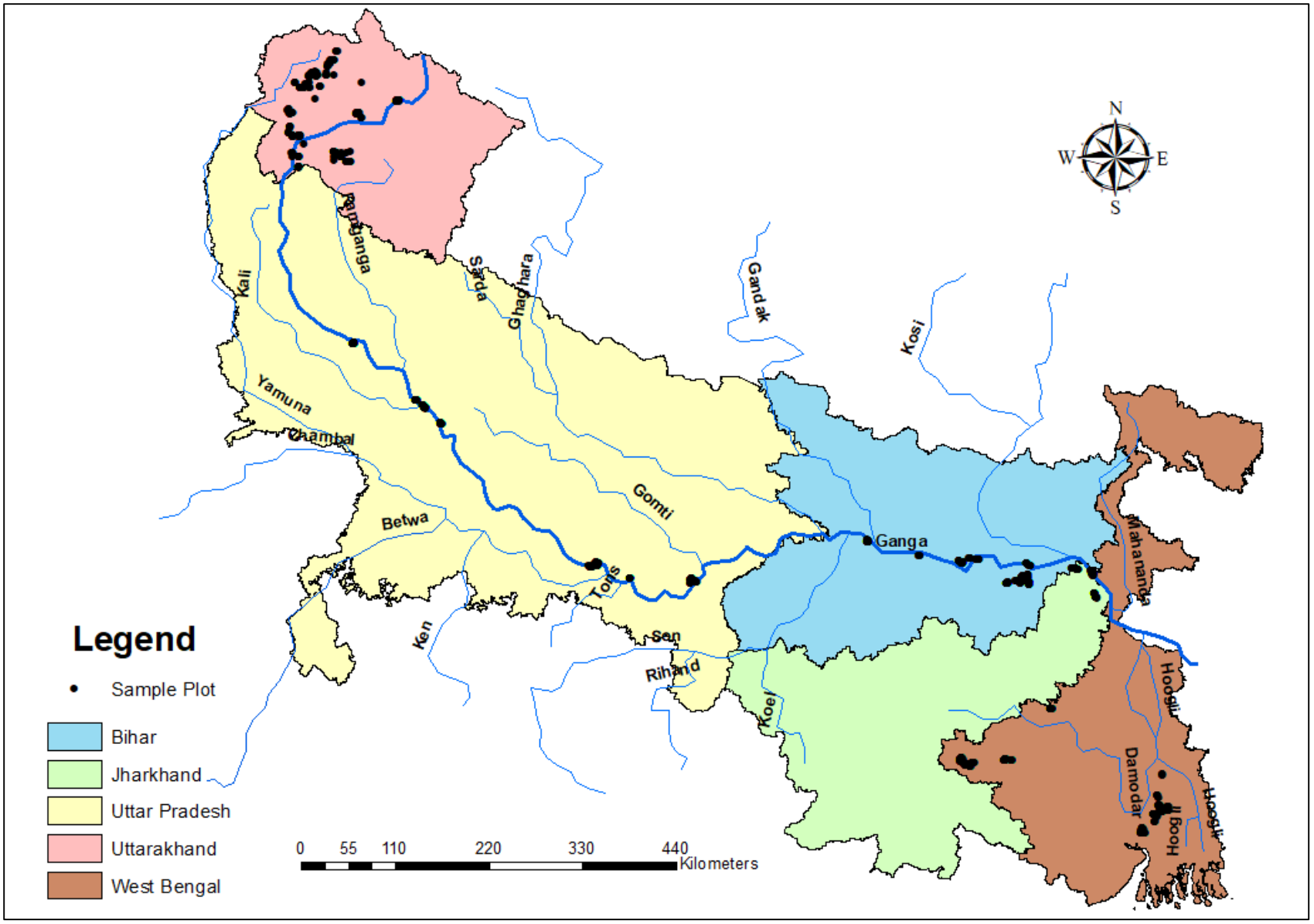

Figure 3.1: Distribution of sample plots of the evaluation study in the five Ganga bearing states

3.2.2 Sampling plants within a project site

There were three types of plantations sites, block plantations, linear plantations and farm plantations. Accordingly, three different types of sample plots were designed to sample plants within a project site.

3.2.2.1 Data collection in block plantation sites (Figure 3.2)

- A reconnaissance survey by traversing the plantation site to develop familiarity with the locality factors.
- A sampling intensity of 5-10% in terms of number of plants planted was used after verifying with the survival percentage-area saturation curve.
- Plots of 25mx25m were laid within the site in a geographically representative manner covering the total plantation area.
- In few locations in the upper reaches of Uttarakhand, smaller sized plots and a lower sampling intensity of 2-5% had to be resorted to due to inaccessibility.
- Within each sample plot, the geographic coordinates were recorded for all the four corners using the Locus Map application on a smartphone.
- Within each of these sample plots, total enumeration of all the planted seedlings was carried out for survival, and the growth parameters (girth and height) were measured for every 5th plant.
- At the time of field enumeration, the field staff of the forest division were also present.

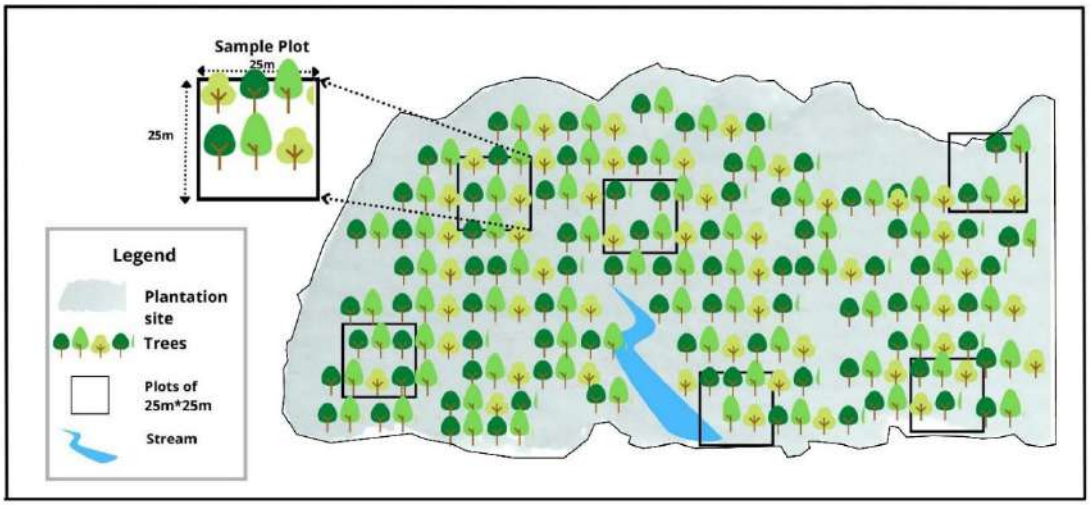

Figure 3.2: Layout and distribution of sample plots within a block plantation site

3.2.2.2 Data collection in a linear plantation sites (Figure 3.3)

- The linear plantation sites evaluated included roadside, riverside, canal side and railway track plantations. These plantations include trees planted in single row, double row and multiple rows.
- We first traversed the plantation site to create a georeferenced arc using the Locus map application.

- To implement a sampling intensity of 10%, a sample segment of 50-meter length was taken at every 500-meter interval.
- While traversing all the plants were enumerated for survival, and the growth parameters (girth and height) were measured for every 5th plant.
- At the time of field enumeration, the field staff of the forest division were also present.

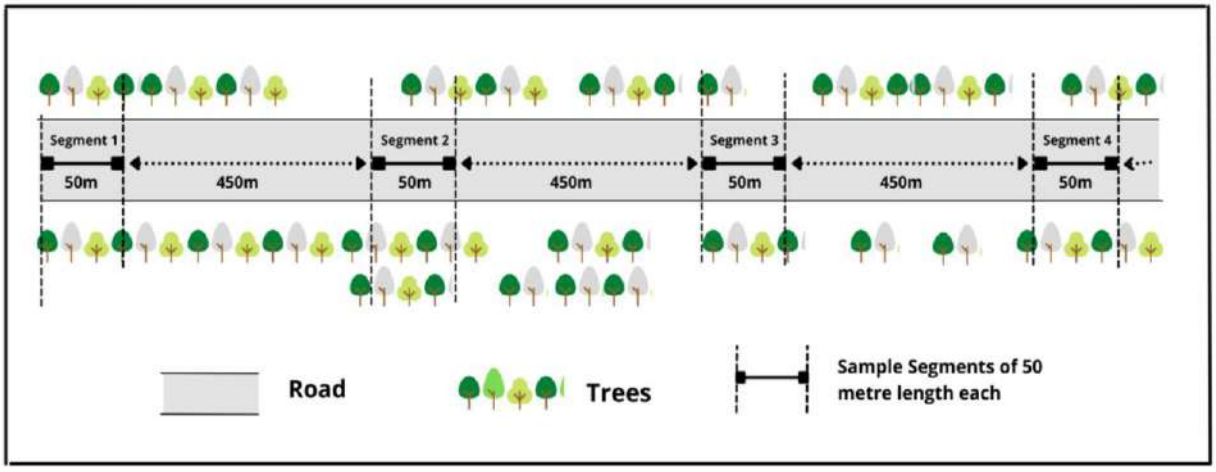

Figure 3.3: Layout and distribution of sample segments within a linear plantation site

3.2.2.3 Data collection in agricultural Landscape (Figure 3.4)

- The commercial trees were planted in the farms either in the agricultural fields or in the homestead.
- Within a village, the households were selected based on the accessibility.
- All the trees present in the household site were enumerated for survival and growth parameters (girth and height) were measured for every 5th tree.
- At the time of field enumeration, the field staff of the respective forest division were also present.

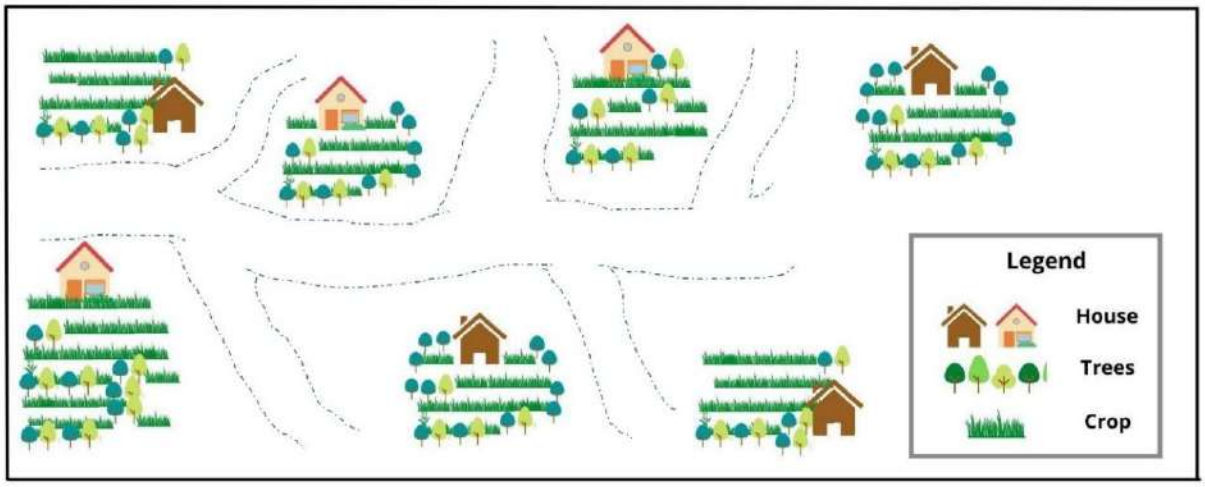

Figure 3.4: Sample strategy in the agricultural landscape

3.3 Data collection methods

Both quantitative and qualitative methods were applied for assessing the success of the plantations (Table 3.5). The quantitative methods are described in Section 3.2 above, the qualitative methods included key informant interviews and expert panel.

Table 3.5: Mixed methods used for evaluating the plantations

Method	Description	Usage
Primary data		
Direct field observation	Observation in the field site using basic tools like GPS, camera etc. for quantitative enumeration	Assess the effectiveness of the plantation by measuring indicators like height, survival, extent etc.
Key informant	Qualitative in-depth interviews with those who have first- hand knowledge of the initiative operations and context. These could provide particular knowledge and understanding of problems and recommend solutions	Assess the gap areas of the 'relevance', 'good practices' and the way forward as to how the effectiveness of the future plantations can be enhanced (Figure 3.5, 3.6)
Expert panel	Officials with experience of managing NMCG projects to provide input on technical or other topics covered by the evaluation. This was carried out in mid May 2022 in online mode.	Assess the difficulties and gap areas in planning, monitoring and implementation and best practices on how the effectiveness of the plantations can be enhanced
Photos/images	Good resolution photos to document the process and outputs along with google earth images of before and after	Assess the extent of the plantation using google earth images, document the evaluation process, stakeholders involved along with the outputs achieved
Secondary data		
National and State level	Details of NMCG plantation projects including financial (allocations, sanctions, expenditure), physical (planning process, approved projects, various government directives etc.) and monitoring (internal monitoring reports, government directives etc.)	To assess the physical and financial allocations and targets, planning and policy framework, difficulties faced in implementation etc.
District level and below	Project proposal, estimate, sanction order, work commencement order, plantation journal, compartment history, working plan prescriptions of the compartment, completion reports,	To assess the physical and financial targets of the projects, planning and implementation of the individual projects, inputs and outputs relating to the projects.

	photographs, monitoring reports, GPS points etc.	

Figure 3.5: Key informant interview with forest officials at Begusarai forest division

Figure 3.6: Key informant interview with forest officials at Purulia forest division

3.4 Field work plan

The field data collection scheduled in April 2021 was affected by the COVID 19 Delta wave and commenced only in July 2021. We started with Bihar and Jharkhand and in mid-August the Ganga was in spate in Bhagalpur and Jharkhand, and North Bihar was flooded (Figure 3.7, 3.8). The field team used the break to complete the data entry and plan for the next stage. We restarted in early September 2021 from the state of Uttar Pradesh and found that only the urban plantations were accessible as the river side plantations were submerged under several feet of water (Figure 3.9). So the team then moved to Uttarakhand in early October 2021 and again lost a week due to heavy and late monsoon rains (Figure 3.10). The project deadline was Dec 2021 but due to these reverses, a no-cost extension was granted till June 2022. It was only from Nov 2021 that the work picked up and the evaluation team was supplemented to make up lost ground. So while one team continued in Uttarakhand, the other returned to complete the left over sites in UP, Bihar and Jharkhand (Figure 3.11, 3.12). This way by early January 2022 the team had completed the four states of Bihar, Jharkhand, UP and Uttarakhand. We used the months of Jan-Feb 2022 for data entry, data analysis and report writing of these four states when the COVID third wave was active. The data collection for the state of West Bengal was completed in March 2022 (Figure 3.13, 3.14, 3.15).

Figure 3.7: Field data collection in the flooded landscape of Sahibganj, Jharkhand with the established plantations in the background

Figure 3.8: Field data collection affected by floods in Bhagalpur, Bihar

Figure 3.9: Field data collection affected by floods in Hardoi, Uttar Pradesh

Figure 3.10: Plantation evaluation in the rugged mountain terrain of Uttarakhand

Figure 3.11: Plantation evaluation in the tall riverine grasslands of Ganga Khadar in UP

Figure 3.12: Riverine plantation enumeration underway in Sahibganj, Jharkhand

Figure 3.13: Enumeration of plantations taken up in the natural landscape in Purulia, West Bengal

Figure 3.14: Community consultation in the natural landscape at Birbhum, West Bengal

Figure 3.15: Enumeration of urban plantations underway in Nadia district, West Bengal

3.5 Data analysis

For each sampled site we generated the following three field-level datasets: (i) Plantation enumeration form, (ii) Plantation summary form and Key Informant Interview (KII) with the forest personnel (Figure 3.16). The data was then analysed in Microsoft Excel using the pivot table function and the following five outputs were generated: (i) A table showing the species selected for plantation and their proportion, (ii) A table showing the growth (height and girth) of the plants, (iii) A table indicating the cumulative survival percentage with area sampled. This curve helps in assessing the adequacy of the sampled area (iv) Google earth images (before and after) showing the location of the sample plots and (v) select photographs.

3.6 Policy analysis of the programme design

Along with the experience gained in this evaluation, we also carried out a review of the global best practices on ecological restoration. Using this lens to analyze the policy design of this programme as elucidated in the Forest Research Institute DPR (FRI DPR 2016).

Figure 3.16: Data analysis and report writing was carried out at IIFM Bhopal

3.7 Enhancing the credibility and legitimacy of the evaluation

Evaluation needs to be credible and provide the real picture of the ground situation in terms of what is working and what is not and why. Implementing agencies can bias an evaluation by showcasing projects that performed better than average thereby biasing the entire exercise. Hence, it is vital that the sites to be sampled are selected solely by the evaluating agency. In this evaluation all the sites to be evaluated where identified meticulously based on a sampling criteria by IIFM and disclosed to the state forest departments only when the evaluation was set to begin. The second yardstick of an effective evaluation is repeatability. All the sample plots within a project site were geo-tagged and this enabled the results to be crosschecked and verified at a later date if needed. Inter-evaluator bias was avoided by getting the field evaluation team to work together for several months before bifurcating them into two teams. Further, data was collected from multiple sources such as field enumeration, informant interviews, field photographs and google earth images and triangulated to enhance the credibility of the study. Google Earth historical imagery function was used for change detection to assess the before and after status of the plantations. To enhance the legitimacy of the study all the key stakeholders namely the state forest departments and the senior NMCG officials were involved in all the stages of the study. A launch workshop was held on 18th March, 2021 with participation from all the state forest departments and NMCG. This workshop enabled a shared understanding of the evaluation framework, scope of the study, sampling design and the issues involved. The interim findings and field reports were also shared with them on a monthly basis. Wherever possible senior officials were consulted (Figure 3.17). Also the draft report was shared with each of the five state forest departments

and discussed with them in a consultation workshop organized with each of the states separately. These consultations were held for Uttar Pradesh state on 10th May, Bihar on 11th May, Uttarakhand on 12th May, Jharkhand on 13th May and West Bengal on 19th May (Figure 3.18).

Figure 3.17: Engaging with senior officials and sharing the evaluation findings with them

Figure 3.18: Online consultation workshops were organized in mid May 2022 with each of the five states in which the draft evaluation report was discussed threadbare and a shared understanding was developed on the field issues and the way forward

The objective of these workshops was to discuss all the suggestions threadbare and to ascertain whether they were practical and workable. The draft report was well received by all the states and they were in agreement with the suggestions made. These consultations ensured that the domain knowledge of the state forest departments was utilized in making the suggestions more practical and workable without impacting the authenticity of the evaluation findings. It also resulted in a better shared understanding of the field issues, possible options available and the most feasible solution to plan out the way forward. Based on these consultations, the draft final report was fine-tuned and submitted to NMCG on 23rd May, 2022. A presentation of this report was made on 17th June, 2022 to NMCG in a meeting chaired by the DG NMCG. Based on the feedback obtained in this meeting, the report was finalized. We hope that this participatory exercise will lead to a stronger ownership of the report by the state forest departments resulting in a faster adoption of the suggestions into policy and practice during the next phase of this programme.

3.8 Limitations of the study

One of the limitations of the study is that the extent of the plantations could not be assessed. In the case of linear plantations taken up along roadsides, railway tracks etc. the plantations were not uniform in the form of a single tree avenue on either side as envisaged earlier. In places where there was ample space available on the road side, the trees were planted in multi-row. In locations where there was no space available by the road side (i.e. due to proximity of shops), trees could not be planted in that stretch. In the case of block plantations, as the boundary of the plantations was not demarcated on the ground in most of the locations, it was not possible to identify it during evaluation as well. The sampling approach focussed on the trees planted rather than the area coverage. Also, as the expenditure incurred is directly correlated to the number of trees planted rather than the area covered this was a realistic approach. While selecting the afforestation projects purposive sampling was done by prioritizing larger projects and districts with higher investments. Some sites in Uttarakhand were on steep slopes and only certain portions of the plantations were accessible. In these sites we laid smaller sized plots and the sampling intensity had to be also reduced to 2-5% due to the nature of the topography and terrain, as only the accessible portions could be sampled. The study has adequately captured the variability within most of the sites which is confirmed by the saturation of the survival percentage-area curve.

Chapter 4
Uttarakhand State

4.1 Restoration context

Uttarakhand is a Himalayan state characterized by wide variation in elevation, terrain and climate. This results in the creation of ecological niches and ecotones which support unique floral assemblages. Due to the presence of these microhabitats, the selection of species suitable to a site is a complex decision. Also, Himalayan ecosystems are characterized by remoteness, inaccessibility, fragility and diversity, and are subject to both natural and anthropogenic drivers of change. These ecosystems face frequent cloud bursts, forest fires, landslides and erosion. In addition, steep slopes, unconsolidated formations, eroded strata, limited growing period, shallow soils, water scarcity in summer and labor shortage make afforestation a challenging task. Due to remoteness and accessibility issues, transportation and carriage are time taking and costly. Plantations taken up in Uttarakhand spanned across three elevation zones namely, lower (less than 1000 m), middle (1000 - 1800 m) and upper (1800 – 2900 m). In the higher zone, landslides were frequent, while in middle zone frequent forest fires and water stress were the main issues. In the lower zone, high grazing pressure and spread of invasive species were the main threats. In the middle and upper elevation zones, it is difficult to come across extensive patches of degraded forests.

4.2 Sampling design

In Uttarakhand a total of 375 plantations were carried out in the three different landscapes viz. natural, agricultural and urban (Figure 4.1). An investment of Rs. 28.09 crores made by NMCG during 2016-17, 2017-18, and 2018-19. The highest investment was made in the Uttarkashi division, followed by Tehri and Tehri Dam 2 (Figure 4.2). The forest divisions for sampling were selected based on the investment, elevation gradient and convenience. A total of 10 forest divisions across the gradient of elevation were selected in.

Figure 4.1: Plantations were carried out in natural, agricultural and urban landscapes

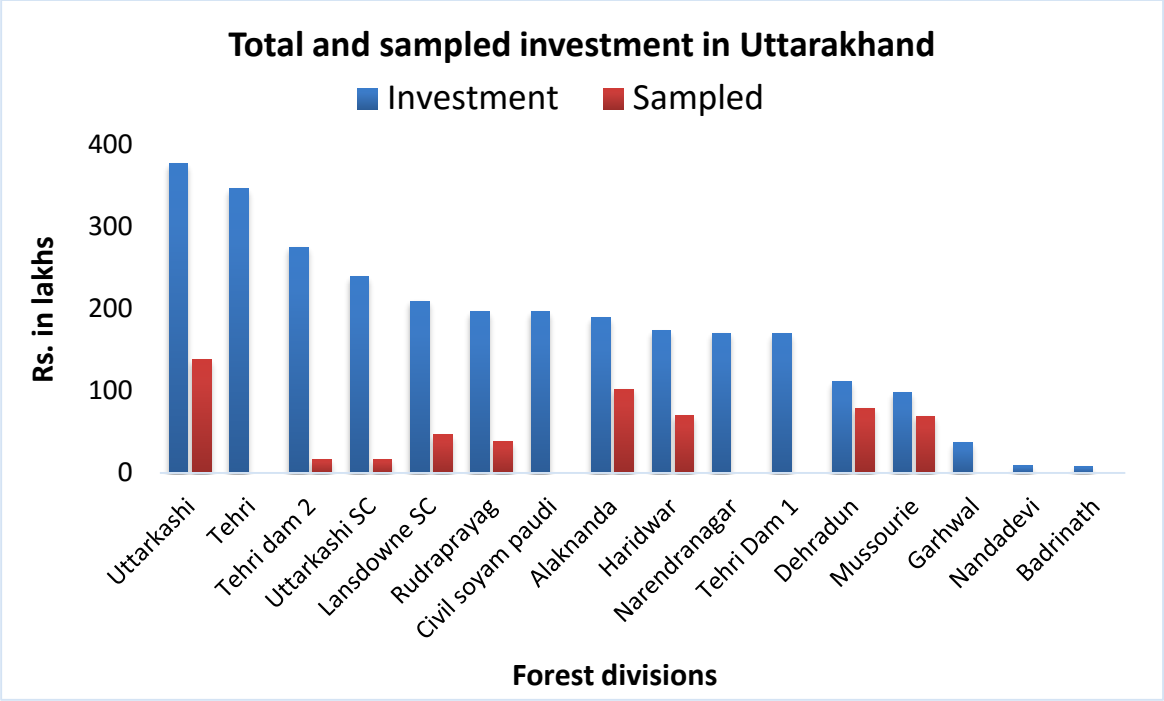

Figure 4.2: Forest division wise total and sampled investment

A stratified sampling approach was adopted with a sampling intensity of 20% of the expenditure. We sampled 56 sites (47 NL, 3 UL and 6 AL) in 10 divisions (Figure 4.3) having a total investment of Rs. 5.78 crores. The sampled sites were selected (Table 4.1) to cover the different elevation zones ranging from low altitude (from 200 to 1000 m) to mid-altitude (1000 to 1800 m) and high altitude (1800 to 2900 m). The details of the forest divisions and ranges sampled are shown in Table 4.2.

The plantation models covered in the evaluation, were NL/H/03, NL/H/06, NL/H/07, NL/H/08, NL/H/09 and NL/H/11 in the natural landscape, UL/A/01 in the urban landscape and AL/H/01 in the agricultural landscape. These plantation models are prescribed in the ICFRE DPR and details are provided in Annexure 10.3.

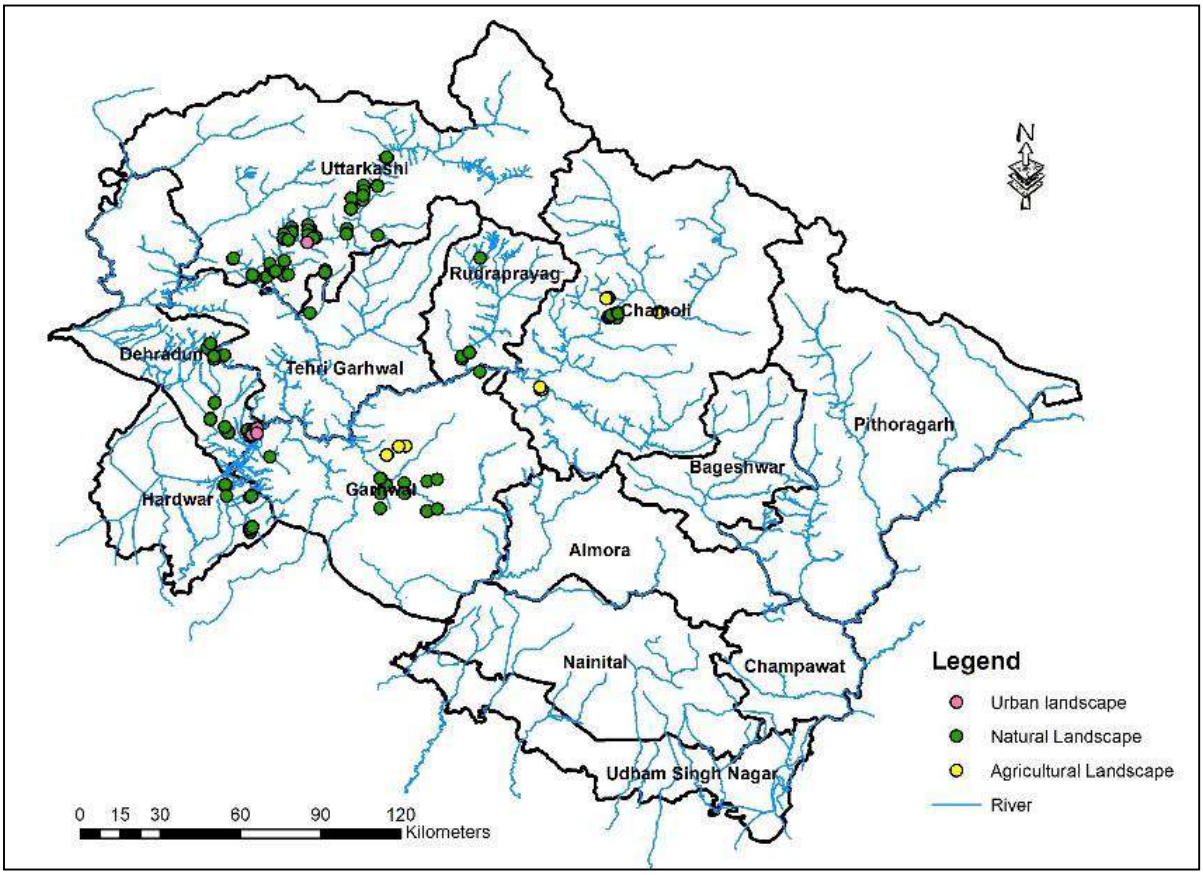

Figure 4.3: Distribution of sample plots in the evaluation study

Table 4.1: Elevation zones of the sampling sites

	Elevation zone	Division	Range
1	Low altitude zone (200 to 1000 m)	Dehradun	Lachhiwala, Barkot and Rishikesh
		Haridwar	Chidiyapur and Shyampur
		Mussoorie	Raipur
		Lansdowne SC	Jayharikhal
2	Mid altitude zone (1000 to 1800 m)	Uttarkashi	Barahat, Mukhem, Dunda, Dharasu
		Lansdowne SC	Jayharikhal and Rikhnikhal
		Rudraprayag	South Jakholi, Rudraprayag and Agastyamuni
		Uttarkashi SC	Jalkurgad Pratham and Indravati Raji
		Tehri Dam 2	Daskigaad
		Alaknanda ETF	Alaknanda ETF
		Mussoorie	Mussoorie
3	High altitude zone (1800 to 2900 m)	Uttarkashi	Taknour and Gangotri
		Nanda Devi NP	

Table 4.2: List of project sites sampled in Uttarakhand

Year	Division	Model No.	Project Name	No. of plants	Cost in lakhs
2018-19	Lansdowne	NL/H/08	Satpuli Malli	10,000	7.76
2018-19		NL/H/08	Bhayali	10,000	7.76
2018-19		NL/H/08	Bhali	10,000	7.76
2018-19		NL/H/08	Uneri 2	10,000	7.76
2018-19		NL/H/08	Bhali 2	10,000	7.76
2018-19		NL/H/08	Chaukadi	10,000	7.76
2017-18	Alaknanda	NL/H/11	Tangari/Patal Ganga	107,000	102.36
2017-18	Uttarkashi	NL/H/07	Nald-1	10,000	8.72
2017-18		NL/H/07	Kawa 3B	10,000	8.72
2018-19		NL/H/07	Utrao 5A	10,000	8.37
2017-18		NL/H/07	Sauragarh 3A	10,000	8.72
2017-18		NL/H/07	Dilasaud 1	10,000	8.72
2018-19		NL/H/07	Nirakot 2	10,000	8.37
2018-19		NL/H/03	Hurri 6A	10,000	8.37
2018-19		NL/H/03	Tihar 6 B	10,000	8.37
2017-18		NL/H/03	Raithal 5A	10,000	8.72
2018-19		NL/H/03	Sukhi 1A	10,000	8.37
2017-18		NL/H/07	Dharasu 3	10,000	8.72
2017-18		NL/H/07	Badethikhand 2	10,000	8.72
2018-19		NL/H/07	Kandaak 2 (1)	10,000	8.37
2017-18		NL/H/07	Dhanari 1, Plot 1	10,000	8.72
2018-19		NL/H/07	Gamri 2	10,000	8.37
2017-18	Uttarkashi SC	NL/H/06	Dikholi Soyam 2	10,000	8.43
2017-18		NL/H/06	Chamkot	10,000	8.43
2017-18	Tehri dam 2	NL/H/06	Kathogi Soyam	10,000	8.43
2017-18		NL/H/06	Hatnali Soyam	10,000	8.43
2018-19	Rudraprayag	NL/H/07	Rudraprayag Reserve 10A	10,000	9.84
2017-18		NL/H/07	Ratanpur 11	10,000	8.80
2018-19		NL/H/07	Jakhal 10	10,000	9.84
2018-19		NL/H/07	Tolab Van Panchayat	10,000	9.84
2017-18	Haridwar	NL/H/08/09	Sambalgarh 5 (30ha)	30,000	23.30
2017-18		NL/H/08/09	Sambalgarh 5 (20ha)	20,000	15.53
2017-18		NL/H/08/09	Pili 2 B	15,000	11.65
2017-18		NL/H/08/09	Anjani 1&2	25,000	19.42

2017-18	Dehradun	NL/H/08	Fatehpur Block	15,000	11.90
2018-19		NL/H/08	Vanvah 1	10,000	7.93
2018-19		NL/H/08	Chandi 1	15,000	11.89
2017-18		NL/H/08	Chandi 2	10,000	7.93
2018-19		NL/H/08	Bibiwala 7B	10,000	7.93
2018-19		NL/H/08	Lalpani 2	15,000	11.89
2017-18		NL/H/08	Lalpani 2	10,000	7.93
2018-19	Mussourie	NL/H/08	Bandal 1	10,000	7.71
2018-19		NL/H/08	Bandal 1 Part 1	10,000	7.71
2018-19		NL/H/08	Chamasari 1	20,000	15.43
2018-19		NL/H/08	Sripur 2 B	20,000	15.43
2018-19		NL/H/08	Dwara 6 (10ha)	10,000	7.71
2018-19		NL/H/08	Dwara 6 (20ha)	20,000	15.43
2016-17	Uttarkashi	UL/A/01	Lambgaon Motor Marg	2,700	9.58
2016-17	Dehradun	UL/A/01	Rishikesh-Haridwar NH (4-11KM)	1,100	12.00
2016-17	Dehradun	UL/A/01	Rishikesh- Haridwar NH (Van Nigam Depot)		
2017-18	Alaknanda	AL/H/01	Diyarkot	200	0.013
2017-18	Alaknanda	AL/H/01	Jakh	120	0.0076
2017-18	Nanda Devi	AL/H/01	Debgram	120	0.0108
2017-18	Nanda Devi	AL/H/01	Tapovan	135	0.0121
2018-19	Uttarkashi	AL/H/01	Dharali	200	0.0168
2018-19	Uttarkashi	AL/H/01	Sukki	100	0.0084
			Total	**666,675**	**577.69**

4.3 Findings

The findings were grouped under three headings namely: relevance, effectiveness and sustainability as described below.

4.3.1 Relevance

The relevance component covered site and species suitability as discussed below:

4.3.1.1 Site suitability

Several factors determine the site suitability of the plantation sites. Sites with dense forests need to be avoided. While sites impacted by heavy grazing, frequent forest fires and spread of invasive species need to be either avoided or taken up only after the drivers of degradation have been controlled or adequate mitigation steps have been put in place. These site suitability factors are discussed in more detail below:

A. Plantations carried out under dense forests showed poor growth

It was found that plantations carried out in dense forests showed stunted growth due to the poor penetration of sunlight (Figure 4.4). In the state of Uttarakhand it is difficult to come across large patches (> 4 ha) of degraded forests in the mid and high elevation zones (1000-2900m), hence some portion of the plantations extended below the dense forests also. On the other hand, plantations carried out in degraded forests performed better (Figure 4.5).

Figure 4.4: Afforestation carried out in dense Khair (*Acacia catechu*) forests

Figure 4.5: Plantation carried out in degraded forests using native species

B. Landslides and soil erosion

In Uttarakhand, deforestation and forest degradation are the main causes attributed to soil erosion on steep slopes[2]. Recent studies[9] show that Uttarkashi and Rudraprayag have lower soil erodibility factor (the ability of soils to resist erosion), indicating the importance of afforestation in these localities. ETF officials informed that in 2018, approximately 1700

[9] Mahapatra et al. 2018

saplings were damaged due to the landslide (Figure 4.6). To mitigate this problem, soil anchoring species like Devdar, Ringal (Bamboo), Surai etc. were planted in these areas.

Figure 4.6: Landslide damaged a portion of the plantation at Patalganga ETF, Alaknanda

C. Homestead plantations

In the plantations carried out in agricultural fields and homesteads, predominantly horticultural species of economic value were chosen to involve the farmers. In the 6 sampled sites, 3 horticultural species, e.g. Seb, Akhrot and Chuli were planted. Plants were grown mainly in homestead (kitchen gardens, lawns and backyards) and crop fields. Trees planted in the farmer's homestead showed better survival compared to the ones planted in the agricultural fields as they were tended regularly and watered.

D. Forest fire

In the mid altitude areas, mixed plantations were established below the canopy of Chir Pine. These plantations were found to be impacted the most by forest fire. In Rudraprayag division, the plants were damaged by forest fires (Figure 4.7). However, the forest department carried out casualty replacements immediately afterwards.

Figure 4.7: The forest fire in Rudraprayag division

(photo credit: Rudraprayag forest division)

E. Cattle grazing

Cattle grazing is one of the most important factors to be considered for any afforestation or reforestation project. During the evaluation, grazing pressure was observed in most of the plantation sites. High grazing pressure was observed in the lower elevation zone in the sampled sites of Haridwar division as they were taken up adjacent to the "Gujjar" relocated villages, adversely impacting the plant survival (Box 4.1).

Box 4.1: Block plantations in Haridwar Forest Division

The block plantations in Haridwar forest division impacted by high grazing pressure and abundance of Lantana. These plantations were situated close to the relocated Gujjar villages from the Rajaji National Park. The impenetrable Lantana cover (Fig. a) affected the health of the plantation. The plantation boundary was damaged (Fig. b), which resulted in access to the village cattle (Fig. c).

(a) (b) (c)

On the contrary, in the Barkot range of Dehradun division, while the plantations were taken up adjacent to the village, the local community demonstrated a sense of ownership and jointly protected the plantations (Figure 4.8).

Figure 4.8: The plantations in Barkot Range, Dehradun division performed well due to community support

F. Abundance of invasive species

Another problem faced was the abundance of invasive species. This was observed especially in the lower altitude areas, viz. Haridwar division, Dehradun division and parts of Mussoorie division. *Lantana camara* is the predominant species, followed by *Hyptis suaveolens* and *Parthenium hysterophorus* (Figure 4.9). In many places the Lantana cover was so dense that it was nearly impenetrable. The plants under the Lantana cover were found to be stunted. The control of invasive species post-plantation is needed to ensure plantation growth.

Figure 4.9: Abundance of invasive species (*Hyptis suaveolens* and *Lantana camara*) in the plantation site

E. Wildlife impact

Most of the plantations were situated on the periphery or inside forests and were impacted by wild animals. The lower elevation plantations in Haridwar, Dehradun and parts of Mussoorie were damaged by elephants, nilgai, chital deer, wild pig and porcupine (Figure 4.10). Though protection measures like barbed wire fencing were used, elephants damaged the fence at places following which cattle entered the plantation site.

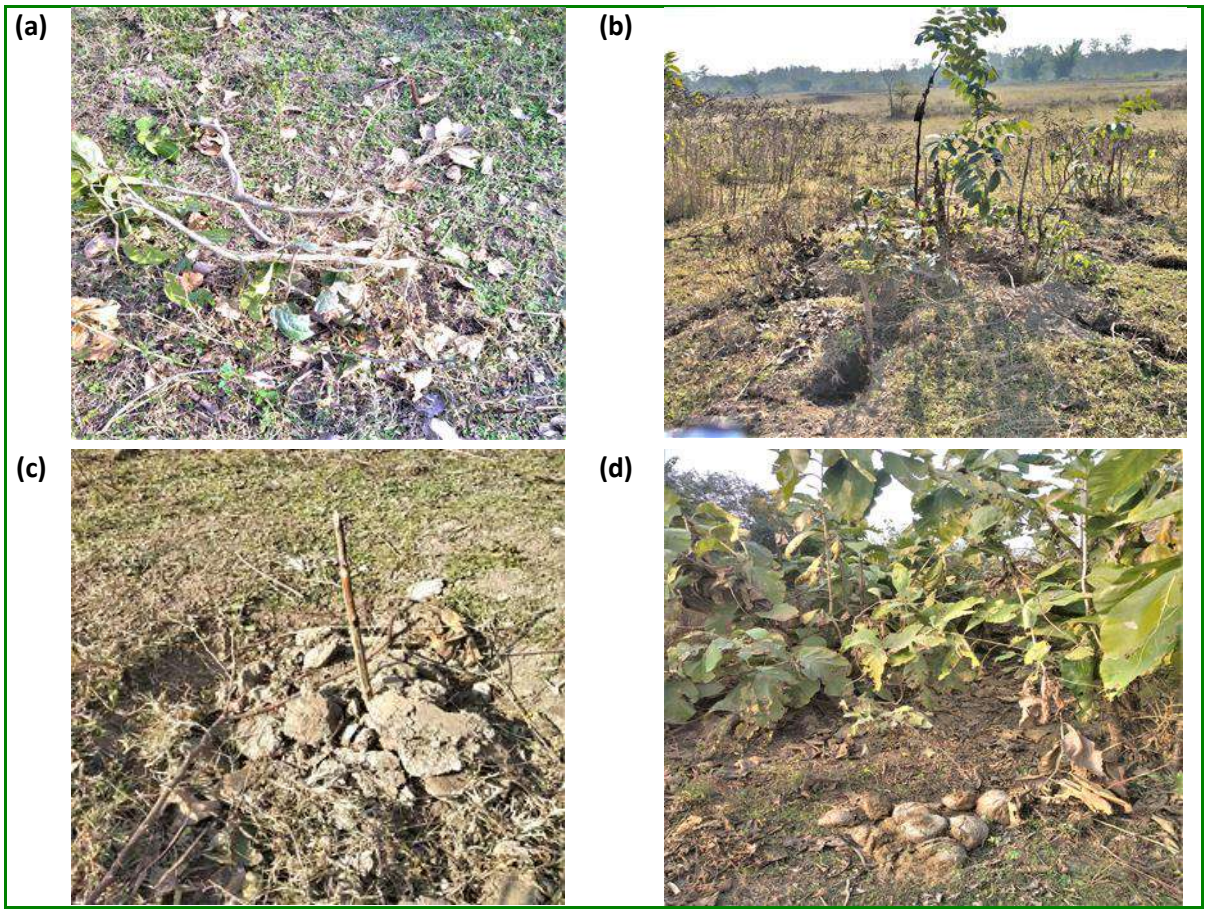

Figure 4.10: Plants damaged by (a) chital deer, (b) porcupine (c) wild pig and (d) Elephant dung inside the plantation area

4.3.1.2 Species suitability

The most planted species were Banjh, Devdar, Kachnar, Sheesham, Bans, Amla, Gingharu etc. (Figure 4.11). The 'others category' in this figure includes Chirol (2.88%), Ber (2.72%), Jamun (2.38%), Surai (2.33%), Kadipatta (2.18%), Karanj (1.93%), Hisar (1.75%), Mahal (1.69%), Kingoda (1.67%), Jungli gulab (1.54%), Gadbhais (1.54%), Ringal (Bamboo) (1.44%), Tun (1.40%), Baheda (1.39%), Akhrot (1.10%), Seb (1.05%) etc. The species selection varied among the three elevation zones. In the low altitude areas, Sheesham and Amla were the most planted species. In mid-altitude areas mainly Banjh, Bans, Devdar and Kachnar were planted.

(c) (d)

In high altitude areas, Buransh, Devdar, Mahal, Ringal (Bamboo) and Surai were planted. In Lansdowne Soil Conservation Division, Banjh was planted under the canopy of Pine forest, the probable reason could be to restore the forest with Banj oak as it has better soil and moisture conservation property and also sustains higher levels of biodiversity. In agricultural landscapes, mainly Akhrot, Chuli and Seb were planted. In avenue plantations, Devdar, Sheesham, Kachnar, Kaner, Tecoma, Gulmohor and Rohini were the most preferred species. The species selection was found to be suitable as mostly native and multipurpose species such as Banjh, Devdar, Kachnar, Sheesham etc. were preferred. Amla, Arjun and Jamun were planted as medicinal species as per the requirement of the FRI DPR. But in most places, these species did not perform well, as they were not acclimatized to the seasonal snowfall and shallow soil depth.

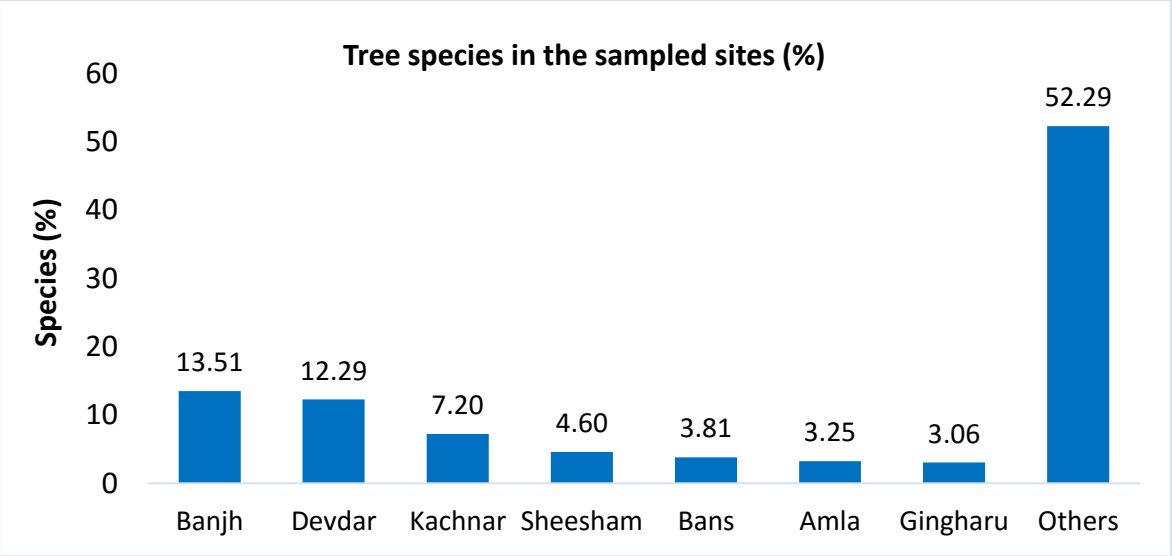

Figure 4.11: Tree species sampled in the afforestation sites of Uttarakhand

4.3.2 Effectiveness

To evaluate the effectiveness of the plantation, two parameters namely- plant survival and growth were taken into account.

4.3.2.1 Plant survival

The overall survival of the plants was found to be very good (84%). The highest survival was found in the plantations in mid altitude zone, followed by the high altitude zone and lowest in the low altitude zone (Table 4.3). The plantations in the low altitude zone faced multiple threats such as cattle grazing, wildlife disturbance (elephants, deer, nilgai, porcupine etc.) and spread of invasive species such as *Lantana* and *Hyptis*. Due to the lack of watering provision, the plants in the low and mid elevation zone suffered from water stress. These plantations were also impacted by forest fire. On the other hand, the plantations in high

elevation zone had adequate natural water sources and the invasive species threat was relatively low.

4.3.2.2 Plant growth

The overall growth of the plantations was found to be satisfactory. The highest plant growth was found in the low altitude zone, followed by mid altitude zone and the lowest was recorded in the high altitude zone (Table 4.3). In the plantations in the low altitude zone, comparatively taller seedlings of fast growing species (Sheesham, Amla, Jamun etc.) were planted. On the other hand, in the plantations of mid to high altitude zone, comparatively smaller seedlings of Deodar, Surai, Banjh etc. were planted.

Table 4.3: Survival and growth of plants in different elevation zones

Elevation Zones	Average of Height (m)	Average of GBH (cm)	Survival %
Low (less than 1000)	2.30	13.93	72.60
Mid (1000-1800)	1.08	5.51	84.35
High (1800-2900)	0.86	5.17	83.75
Weighted Average	**1.48**	**8.59**	**83.62**

4.3.3 Sustainability

In order to ensure long term survival of the plantations, the following measures were used.

a) Fencing measures

The protection measures observed in the plantation sites were stone wall, barbed wire fencing and iron tree guard (Figure 4.12).

Figure 4.12: Protection measures used in the plantation sites: stone wall, barbed wire fencing and iron tree guard

In most of the plantations, especially in the mid-high altitude zone (Lansdowne, some ranges of Uttarkashi, Tehri Dam 2, Rudraprayag, Uttarkashi SC and Mussoorie divisions), stone wall is the main protection measure. However, most of these plantations were found to be impacted by wild pig, deer, etc. Similar problem was reported in the plantations in the lower altitude where barbed wire fencing was used. Here the elephants damage the fencing while the wild pig and chital damaged the plants. In avenue plantations taken up in the urban landscape, iron tree guards were used as a protection measure and were found to be successful.

b) Watch and ward

After plantations, a 3-year maintenance period is provisioned to watch over the plantation and protect it from threats. This work is done by the chowkidaar, appointed from the nearest village. Generally, one chowkidaar is appointed to look after 10 ha of plantation. The survival of the plantations depends almost entirely on the effectiveness of the watch and ward.

c) Soil and moisture conservation works

As discussed in earlier paragraphs, one of the cause of plantation failure was due to the moisture stress/drought. Therefore, soil and moisture conservation in these plantation areas is necessary to ensure survival. Following measures were taken by the forest department to prevent soil erosion and conserve water:

1. Minor irrigation canal systems

Forest area is the major catchment of water supply to the villages. Springs are tapped with the help of small canals to meet the irrigation demand. These systems were effective especially in certain locations like Chamkot and Kathogi (Figure 4.13). However, at times these structures are difficult to manage due to deposition of silt and debris. These can be considered as very effective measures to irrigate the plantations.

Figure 4.13: Minor irrigation canals in plantations of Uttarkashi Soil Conservation division

2. Contour bunding and retention walls

This technique has been used to bind land parcels along pathways, steep slopes and water reservoirs (Figure 4.14). These type of bundings are very efficient for conservation interventions with extensive larger stretches. It was found on the base of the contours in the lower elevation zone of Uttarkashi, Rudraprayag and Mussoorie forest divisions. In addition, dense vegetation growth was observed to strengthen the structure in the plantations of Uttarkashi division and Uttarkashi SC division. Retention walls are constructed as mitigation measures of landslides and soil erosion in steep slopes, whereas contour bunds are made in the plantation areas to reduce the soil loss and augment the moisture, groundwater. Both the structures found to be relevant in the plantations.

Figure 4.14: Contour bund and retention wall in Uttarkashi Soil Conservation division

Figure 4.15: Strategic location of gully plug in Uttarkashi division

3. Gully plugs

As it was observed that soil erosion and bank erosion are some of the causes of land degradation in the area. Gully plugs help in reducing the soil erosion and moisture augmentation (Figure 4.15). Due to torrential rain and flow of water, the gully plugs act as barrier and check the flow and nala cutting. Site specific approaches were observed in Taknour and Gangotri range where plantation of Ringal bamboo behind these structures was done to provide better hold for the soil and more endurance in blocking flash floods.

4. Check dams

Besides gully plug structures, check dams are also equally important in major drainages where erosion is high. Design of these structures and their placement required technical planning as observed in many sites of Uttarkashi, Rudraprayag and Tehri dam 2. The interventions observed in Raithal showed strategic placement of the structures to reduce erosion (Figure 4.16). The interlacing was found to be complete in Dharasu range, where the bonding was extended across the sides to provide additional stability. It was observed that due to these structures, few springs rejuvenated (Figure 4.16).

Figure 4.16: Impact of check dam in Uttarkashi division

5. Soak pits

Rainwater harvesting was found to be very effective in the area. There are different structures made including soak pits. The soak pits are a type of trench and were observed in many plantation sites. The purpose of these pits is to capture the surface flow of rainwater and assist in groundwater recharge as well as increase soil moisture (Figure 4.17). Their

positive influence was observed in the form of increased natural regeneration and growth of planted saplings in Lansdowne, Uttarkashi and Uttarkashi SC.

Figure 4.17: A strategically located soak pit in Lansdowne SC division

6. Village water storage system

Springs are the only source of water during non-rainy season. Tapping of springs was done with the help of cemented tanks in the higher elevation so that gravity flow shall be maintained to supply water to the low lying villages. Under the project, such tanks were constructed in the plantation sites showed positive results in Rudraprayag and Uttarkashi divisions (Figure 4.18). In Taknour Range, Uttarkashi, availability of water confirmed the efficient functioning of these structures.

Figure 4.18: Spring water harvesting tank, Taknour Range, Uttarkashi

7. Closed tank

The quality water supply is an objective, which is met through the construction of closed tanks. These systems collect water in an efficient manner (Figure 4.19). This Intervention was observed in the plantations of Uttarkashi SC division and Taknour Range, Uttarkashi division and had improved the quantity and quality of water supply.

Figure 4.19: Closed tank to supply drinking water, Uttarkashi SC division

4.4 Suggestions

It was found that overall the programme was performing well and these suggestions have been framed to further strengthen this programme.

a) Natural and assisted afforestation models to be permitted in moderately degraded sites

It was observed that few plantations were carried out underneath dense tree canopy, where penetration of solar radiation was low, resulting in stunted growth (Figure 4.20). Instead, deforested or degraded forest lands should be selected for afforestation. Such sites are available only in the lower elevation zone in the districts of Haridwar, Dehradun etc., while in the middle and higher elevation zones (1000-2900 m) elevation, large patches of degraded forests are scarce. The plantation models made available in the FRI DPR for the mid and higher elevation zone of Uttarakhand namely NL/H/02, NL/H/03, NL/H/04, NL/H/05, NL/H/06 and NL/H/07, all prescribe a plantation of 400 trees and 400 shrubs per ha.

Several studies clearly show that success of ecological restoration is higher for natural and assisted regeneration compared to reconstructive restoration in moderately degraded habitats. This result runs counter to the prevailing policy and practice that artificial restoration should be the preferred approach for accelerating the recovery of biodiversity. Restoration science and practice suggests that a more site-specific and diverse restoration strategy with three models of restoration, i.e., natural, assisted and reconstructive based on the degree of degradation would be far more successful.

In moderately degraded areas, it may be a better idea to go for natural restoration or assisted natural restoration, instead of artificial restoration with 800 trees or shrubs/ha. In locations where the soil is intact and diverse seed sources are available, natural or assisted regeneration along with protection measures will perform better than the broad brush artificial restoration. This aspect has been discussed in greater detail in Section 9.3.2. As plantation models are not available for moderately degraded and damaged ecosystems, the broad brush, expensive reconstructive afforestation model is applied irrespective of the site condition.

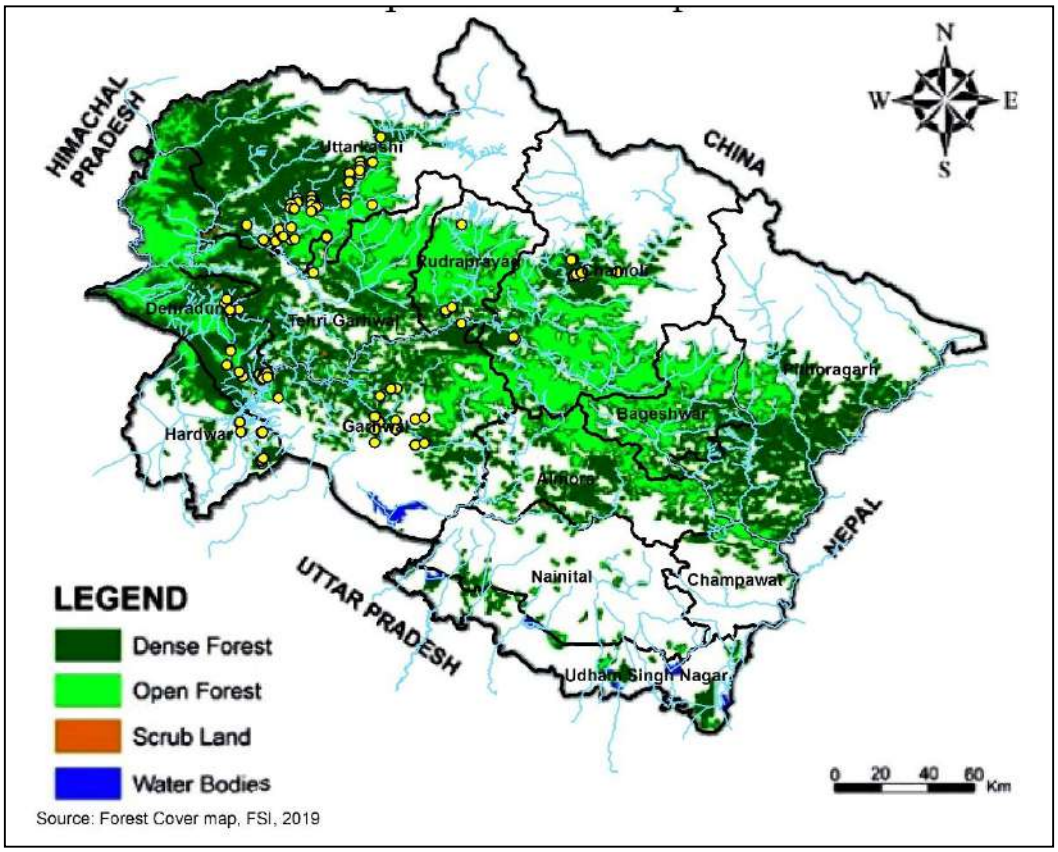

Figure 4.20: Sampled plots indicating plantations carried under dense and open canopy cover

Hence, we suggest that the entire gamut of ecological restoration strategies (natural, assisted and reconstructive) need to be made permissible in the second phase of the "Forestry interventions of the Ganga" for the state of Uttarakhand. Local site specific models that take into consideration the local site conditions and people's needs and are recommended by the state forest departments need to be made permissible, instead of relying on the present approach of a centralized, reconstructive/artificial model. What this would for instance imply is that if there is space for only 150 trees per hectare in moderately degraded and 300 trees per hectare in damaged sites, then the same should be permitted. We suggest that the states

be provided the freedom and flexibility to adapt the existing natural landscape plantation models to the local context so that the field realities are reflected in it. This approach can result in significant cost savings as only need based investments will be made.

b) Addressing the drivers of degradation before planting

Plantations were taken up in in Haridwar district adjacent to a newly established Gujjarbasti village where a large number of Gujjar households had been relocated from within the Rajaji National Park (Figure 4.21). The Van Gujjars are nomadic buffalo-herders inhabiting the foothills of Himalayan states. A total of 50 ha of forest land adjacent to this village was earmarked for taking up block plantations with 1000 trees/ha under NL/H/08 09 plantation models. This site was earlier used for grazing and was also covered with dense, impenetrable thickets of Lantana an invasive alien weed. In the plantation plan while provision was made for fencing, this entry restriction to the grazing lands impacted the livelihoods of the herders. This fence was found to be broken with the cattle grazing inside the plantation area (Box 4.1). Also no provision was kept for the removal of Lantana for which a special plantation model NL/H/10 (Control/removal of invasive species) has been provided in the FRI DPR.

Figure 4.21: Google Earth imagery showing the location of the plantation site (in yellow) adjacent to the relocated 'Gujjarbasti' village

Afforestation projects implemented in isolation without addressing the causes and drivers of deforestation in consultation with the local community will remain a 'band aid' approach to degradation and not provide lasting cure.[10] We suggest that for the natural landscape, the prescribed plantation models need to factor in the ground situation. The main causes of

[10] Blignaut 2009

plantation failure are grazing, drought, frost, fire, floods, landslides etc. These threats existed even before the plantations were planned, and addressing these threats using mitigation and adaptation measures should be made a precondition before planting is taken up. In sites, where this is not possible, plantations should not be taken up as they will probably meet the same fate as the original forests that got degraded. The second option is to adopt a mitigation strategy wherein the design of the plantation model adequately takes into account these threats and risks such as mound plantations in water logged areas, effective fencing in grazed areas, community partnership and ownership, provision of watering during summers etc. Plantations taken up in the absence of these mitigation and adaptation measures, will not meet the desired objectives.

We suggest that freedom and flexibility needs to be provided to the state forest departments to include these components in the existing plantation models based on site specific threat perception and locality factors. Addressing the drivers of degradation before planting will ensure the effectiveness and sustainability of the plantation investments.

c) Active landslide areas should be selected carefully for afforestation

Plantations were taken up to stabilize the active landslide areas and soil anchoring species like Ringal (bamboo), Devdar, Surai etc. were planted. In 2018, according to ETF (Eco Task

Figure 4.22: An active landslide site near the ETF plantation site, Alaknanda division

Force) officials, almost 1700 plants were lost and many others were severely damaged because of the landslide (Figure 4.22). Young plants may get damaged due to lands slips and

boulder falls. Hence, it is suggested that active landslide areas may be selected for plantations only after careful site selection and due diligence. Also, convergence with soil protection projects with plantations may be explored to address the cost issue in planting such areas.

d) Horticulture plantations in agricultural landscape should be scaled up

Horticulture plantations when taken up in the proximity of a homestead were found to be fruitful (Figure 4.23). The horticulture department in consultation with the forest department distributed the species to the villagers. The choice of species, number of plants and planting location needs to be decided jointly with the farmers. Small and marginal farmers also need to be prioritized in this program. Further, it is suggested that these plantations should be done in the proximity of the homestead instead of agricultural fields, so that they can be adequately tended to. These horticulture plantations taken up under the AL/H/01 plantation model need to be scaled up as they are showing good results both for nature and people.

Figure 4.23: A successful horticultural plantation in homestead land, Nanda Devi NP

e) Involving local people in the plantation activities

During the field evaluation, the participation of the people was found to be poor or nil. Before the plantations were taken up, most of the plantation sites were used for grazing of village cattle and firewood collection. Due to this, the prevalence of biotic pressure such as grazing, fire, etc. was observed in many plantations. There is a possibility of involving local people in plantation planning, jointly deciding on site selection, species suitability and planning mitigation measures to ensure greater community ownership of the plantation.

f) The period of post plantation maintenance needs to be enhanced

Presently the maintenance period of plantations in NMCG programs is three years. This may not be appropriate to this mountain state due to various constraints including high rate of casualty, grazing pressure, invasive species, fire and overall low growth factors. Majority of the native species are slow growing and cannot be established in such short period. Further, in the absence of watch and ward after three years, the immature plants become susceptible to anthropogenic and natural threats. Due to a reduced plant growing period in the mountains, it is suggested that the post plantation maintenance period be enhanced from the present 3 years to 5 years. The total duration of the plantation project should be enhanced to 7 years, with the first 2 years kept for raising of nursery seedlings and hardening followed by plantation and maintenance for 5 years. This will strengthen the sustainability of the plantations as they will get enhanced protection from biotic pressure such as grazing, fire and weed infestation, thereby allowing them sufficient time to establish. This was also one of the main issues highlighted in the key informant interview with the field functionaries.

g) Plantations with soil and moisture conservation measures:

Majority of the sample plots fall under moderate to very severe erosion category (Figure 4.24). Therefore, plantation with soil and moisture conservation measures should be a regular practice in these erosion category landscape. These structures made under soil conservation measures were found to be effective and should be enhanced.

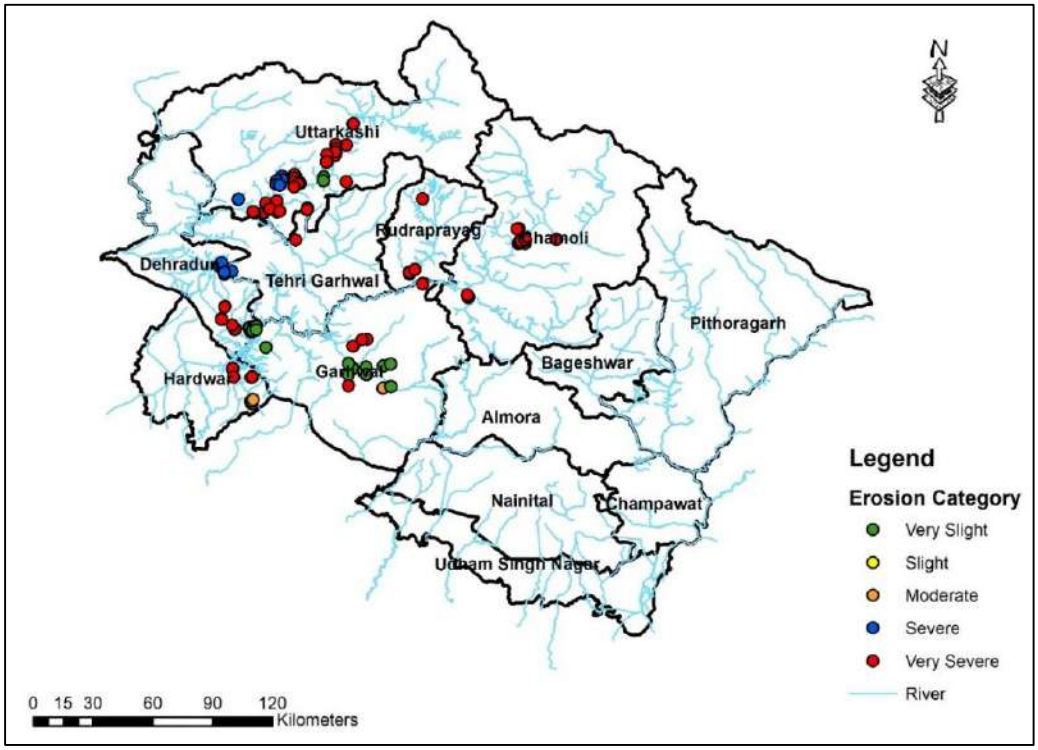

Figure 4.24: Erosion status in the sample plots of the evaluation study

h) Budgetary provisioning for watering and weeding work needs to be included

In the low and mid altitude areas, plantations suffered due to moisture stress during summer. This provision was not kept in most of the plantation sites. We suggest that the feasibility of watering the plantations during the dry season should be assessed and wherever possible included in the plan to secure better results. Further, the abundance of weeds inside a plantation is one of the main problems, especially in low altitude areas. Because of dense cover of invasive species such as *Lantana camara* and *Hyptis suaveolens*, many of the planted species were found to be stunted. Hence it is suggested that in sites with high weed infestation, provision for control of invasive species both pre and post plantation needs to be included in the plantation plan. If these weeds have formed impenetrable thickets, then first these need to be removed for which a special plantation model NL/H/10 (Control/removal of invasive species) has been provided in the FRI DPR and only after that plantations should be taken up.

i) Small seedlings need to be avoided in plantations

In some of the plantations carried out in the mid to high elevation zone, it was observed that small seedlings of less than 0.30 m were used which take many years to establish. Even after 4 years these seedlings have reached only 1 m height (Figure 4.25). Hence, it is suggested that seedlings that are 2-year-old and above and have attained 1 m height should be planted. These seedlings will be more resilient and establish faster. Also, casualty replacement should be preferably done with tall seedlings instead of with seeds or tiny seedlings. The total duration of the plantation project should be enhanced to 7 years, with the first 2 years kept for raising of nursery seedlings followed by plantation and maintenance for 5 years. This will strengthen the sustainability of the plantations

Figure 4.25: Small seedlings of Devdar and Kachnar have attained less than 1 m height even after four years

j) Mandatory medicinal plants component to be discontinued

Most of the plantation models have a provision of 200 medicinal plants to be planted per ha. Due to this, in many natural landscape sites the field personnel were compelled to plant medicinal plants that were not suited to that landscape and consequently did not perform well. The medicinal plants such as, Amla, Arjun and Jamun planted by the Eco Task Force in the Alaknanda division were not acclimatized to the unfavorable weather including seasonal snowfall, rocky soil bed and steep slope, thereby impacting their survival and growth. Thus planting of medicinal plants in the plantation models conflicts with the principle of ecological restoration as the species selected may not be suitable to these ecosystems or the planting material may not be readily available. Hence, we suggest that the mandatory planting of medicinal plants should be discontinued (except NL/H/01). These should be included only when explicitly recommended by the state forest departments under specific contexts while providing reasons for their inclusion.

k) Need for restoring river valleys impacted due to construction activities

Many of the river valleys have been impacted due to dumping of muck, rolling down of excavated material and other construction activities. This has resulted in damage to the riparian ecosystem by way of burying of native vegetation, exposure of soil, higher erosion and sedimentation. Such damaged valley bottoms which are crucial for wildlife management and form an important part of the river biodiversity need to be identified and taken up under restoration. These sites need to prioritized as they are also crucial for ensuring the health of river and should be taken up for restoration under the NMCG project. Site specific estimates may be developed by the state forest department for this purpose, as the existing plantation models of the natural landscape prescribed in the FRI DPR do not cater to this specific context.

l) Delay in wage payment to the chowkidars (watchers)

The main strategy to protect the plantations was by employing the chowkidars. However, most of the plantation chowkidars did not receive their wages in time and often it got delayed by 6-7 months. It is suggested that their wages be released on a monthly basis so that it is possible to keep them motivated and extract work from them. This aspect was also highlighted in the key informant interview with the field functionaries. Also, it is suggested to enhance the number of chowkidars from one per 10 ha presently to one per 5 ha to ensure better plantation protection and its long term sustainability.

4.5 References

Blignaut, J. N. (2009). Fixing both the symptoms and the causes of degradation: the need for an integrated approach to economic development and restoration. *J. Arid Environ*. 73 696-698.

Mahapatra, S. K., Reddy, G. O., Nagdev, R., Yadav, R. P., Singh, S. K., & Sharda, V. N. (2018). Assessment of soil erosion in the fragile Himalayan ecosystem of Uttarakhand, India using USLE and GIS for sustainable productivity. *Current Science*, 115(1), 108-121.

Chapter 5
Uttar Pradesh State

5.1 Restoration context

The alluvial plains of the Ganga fall into three categories - the older upland or flood-free zone called *Bangar*, the younger, flood-prone, lowland known as *Khadar* and the uplands of narrow strips of dry sandy edges known as the *Khola*.[11] All these zones are versatile, productive and have high ecological significance. In addition, these lands are also playing important role in meeting the livelihoods of the local communities. The Ganga riverscape in the state is facing multiple vulnerabilities. It is subject to regular floods and inundation during the monsoon, frost in winter and extremely hot winds and fires during summer[12]. The causes of plantation failure are mainly grazing, drought, frost, fire and floods. Feral cattle (*awara maveshi*) and Nilgai herds are increasingly impacting the survival and growth of the plantations. Waterlogging affects most of the lands along the riverscape during the monsoon which remain waterlogged till the onset of winter. These vulnerabilities limit the choice of species that can be planted in this submergence zone. Further, these areas represent edaphic climax dominated by soil factors. As the conditions are not conducive for tree growth, these areas are covered with tall grasses such as *Saccharum munja*, *Saccharum spontaneum* and *Typha angustifolia* [13] (Figure 5.1).

In the colonial and post-colonial periods, these grasslands were looked upon as weeds and denigrated and devalued relative to forests. Narratives such as “infested with tall grasses” and “control of grasses is essential for tree planting” were prevalent. Without realizing the inherent values of these grasslands, efforts were made to raise tree plantations in the *Khadar* and the *Khola* using mechanized means and permitting farmland lease to control grass growth. The *dola* ridge technique is widely used where after ploughing and harrowing the entire area, seeds are sown on the ridges.[14] Harrowing is done intensively in summer to control grass growth and prevent fire. Frost and drought protection is done by irrigation during summer and winter.

[11] Agarwal 2009
[12] Lal, 1998
[13] Lal, 1998
[14] Lal 1998

Figure 5.1: Riparian areas support luxuriant grasslands that not only stabilize the bank but also filter the runoff

5.2 Sampling design

During the three financial years of 2016-17, 2017-18, and 2018-19, a total of 341 plantation projects were funded by NMCG in the state of Uttar Pradesh. A total investment of Rs. 1836.8 lakh was made during this period, with Rs. 464.01 lakh made in Prayagraj forest division, followed by Hardoi (Rs. 330.34 lakh), Badaun (Rs. 121.5 lakh) and Varanasi (Rs 116.04, Figure 5.2). Hence, a total investment of Rs 1,031.89 lakh was made in these 4 districts which amounts to 56.17% of the total investment made in the state during these 3 years. In the sampling, forest divisions were selected based on the quantum of investment. Thus four forest divisions having the highest investment namely Prayagraj, Hardoi, Badaun and Varanasi were selected for the study (Table 5.1).

The urban landscape plantations were carried out in institutional areas and along the roadside. Mostly ornamental and fruit-bearing trees were selected in these plantations. The natural landscape sites sampled in Hardoi and Badaun divisions were located in the Ganga Khadar. One natural landscape site in Prayagraj division on gram panchayat land was also sampled. Three plantation models were covered during the evaluation namely NL/P/01 (Ganga khadar), UL/A/01 (Avenue plantation) and UL/I/01 (Institutional plantation). In the NL/P/01 model, 625 plants of trees/shrubs, 400 patches of grasses/sedges and 200 medicinal plants were planted per hectare. In the UL/A/01 avenue plantation model, short and medium-sized trees were planted on both sides of the road. In the UL/I/01, ornamental shade and fruit plants were planted in institutional campus.

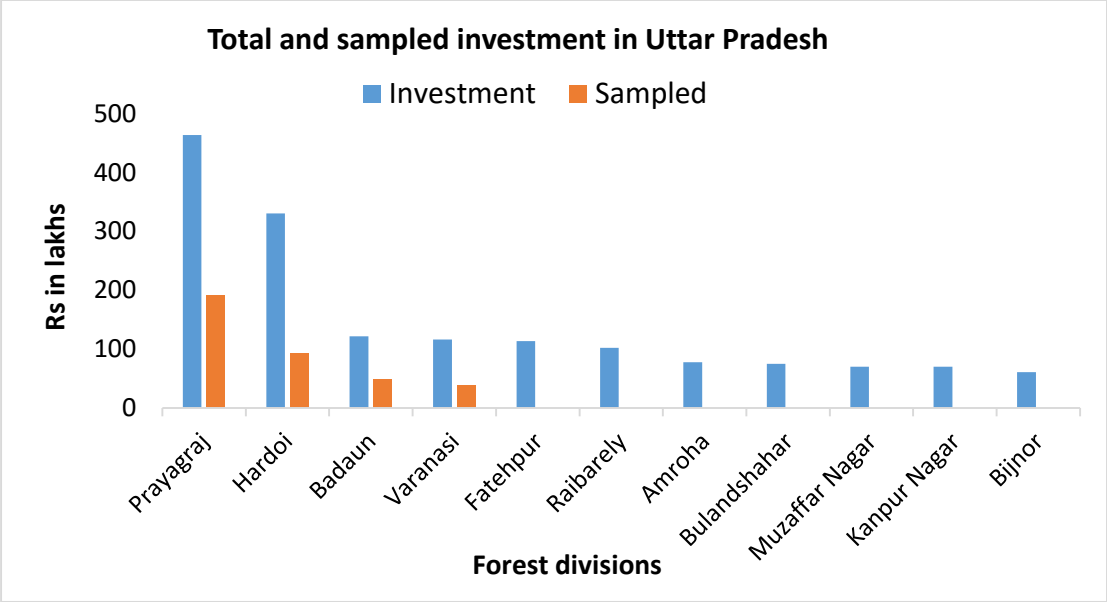

Figure 5.2: The forest divisions of Prayagraj, Hardoi, Badaun and Varanasi were selected for the study

Table 5.1: List of project sites sampled in Uttar Pradesh

Year	Forest Division	Model No.	Project Name	No. of Plants	Cost in Lakhs
2016-17	Prayagraj	UL/I/01	Allahabad University and nearby places	825	18.60
2016-17	Prayagraj	UL/A/01	Govindpur Colony Marg	500	11.30
2016-17	Prayagraj	UL/A/01	New Cantonment area & nearby places	596	13.42
2016-17	Prayagraj	UL/A/01	T.P. Nagar Mundra , Ganga Vihar colony, etc.	410	9.24
2016-17	Prayagraj	NL/P/01	Jaswa Gram Samaj	12500	124.83
2016-17	Prayagraj	UL/A/01	Tagore town, Allapur area, etc.	330	7.43
2016-17	Prayagraj	UL/A/01	Teliyarganj + Mehdauri Colony	300	6.74
2018-19	Hardoi	NL/P/01	Bawatmau Van Block	33000	30.59
2018-19	Hardoi	NL/P/01	Katri Arwal Van Block	20625	19.12
2018-19	Hardoi	NL/P/01	Katri Chochpur Van Block	24750	22.94
2018-19	Hardoi	NL/P/01	Gadanpur Van Block	20625	19.12
2018-19	Badaun	NL/P/01	Ulaikhera	49500	48.60
2016-17	Varanasi	UL/A/01	Ramnagar to Panchwati Marg	100	3.09
2016-17	Varanasi	UL/A/01	Padav to Ramnagar Marg	150	4.63
2016-17	Varanasi	UL/A/01	Balaji Nagar Samneghat	128	3.94
2016-17	Varanasi	UL/A/01	Brijenclave Colony Sundarpur	282	8.74
2016-17	Varanasi	UL/A/01	Gautam Nagar Colony Chitaipur	102	3.17
2016-17	Varanasi	UL/A/01	Shreeram Nagar colony	100	3.09
2016-17	Varanasi	UL/A/01	Sivajee Nagar Colony	100	3.09
2016-17	Varanasi	UL/A/01	Nirala Nagar Colony	250	7.71
Total					**369.37**

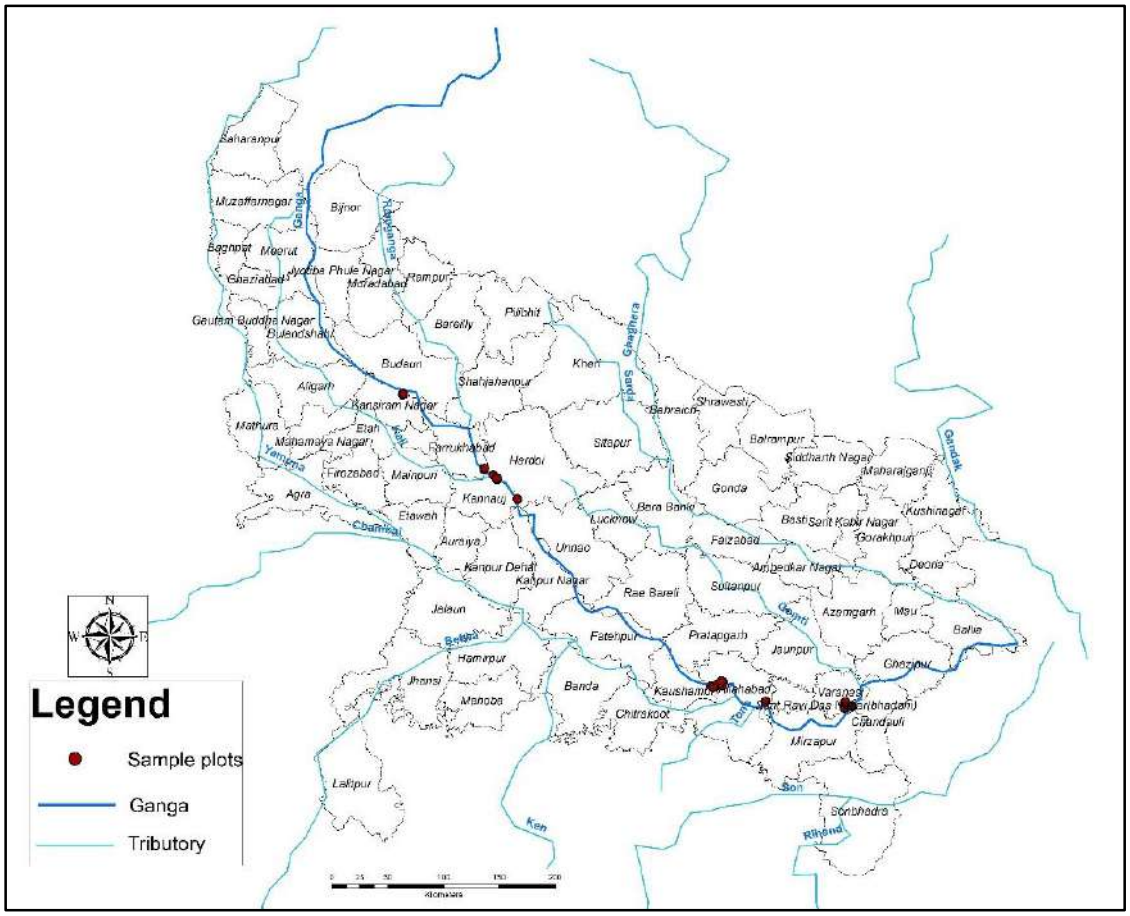

Figure 5.3: Distribution of the sample plots of the evaluation study

5.3 Findings

The findings were grouped under three headings namely, relevance, effectiveness and sustainability as described below.

5.3.1 Relevance

The relevance component covered suitability of the site for tree plantations and species selection.

5.3.1.1 Site suitability

The Ganga Khadar is narrow belt of low lying lands along the upper reaches of Ganga and its tributaries in between the *Doab* of Ganga-Yamuna. These areas experience regular floods and inundation from June to September, frost during winter and extremely hot winds and fires in summer.[15] These riparian grasslands are the world's tallest, stabilize the bank and also filter the runoff. These grasslands are amongst the most productive, rare and also the most

[15] Lal 1998,

threatened. Since the colonial era, these grasslands were undervalued and large tracts were converted into woodlands. Many researchers have evaluated the importance of these ecosystems and advocated the ill effects of such grassland conversion on native flora and fauna[16,17]. With advancements in the science of landscape ecology and ecosystems services, these effects are now better understood. In the FRI DPR as well, tree/shrub plantation was proposed in the Ganga khadar area, using the NL/P/01 model (Box 5.1).

Box 5.1: Tree plantations taken up in the Ganga khadar in Hardoi forest division

The images below show tree plantations taken up in the Ganga khadar grassland along the bank of the river Ganga. *Prosopis juliflora* was the most preferred planted species. The abundant grass growth had (Figure a) suppressed the planted species such as Khair, Babool, Kat Sagaun, Chirol etc. This grassland forms the habitat for Nilgai, Chital and other wild animals and their impact on the saplings was also observed (Figure (b)).

(a) (b)

5.3.1.2 Species suitability

Species such as Jungle Jalebi, Prosopis, Babool, Ber, Sheesham, Karanj, Khair and Ficus were preferred planted species (Figure 5.4). The growth of *Prosopis juliflora* (vilayati babool) was high as compared to the other planted species. But it is reported as a severe invasive species[18,19] as in a very short period, it grows abundantly and forms dense, impenetrable thickets[20], which eventually eradicate almost all other native species under it (Figure 5.5).

[16] Michael et al. 2017
[17] Shrutarshi et al. 2021
[18] Kaur et al. 2012
[19] Pasiecznik et al. 2001
[20] Mwangi and Swallow 2008

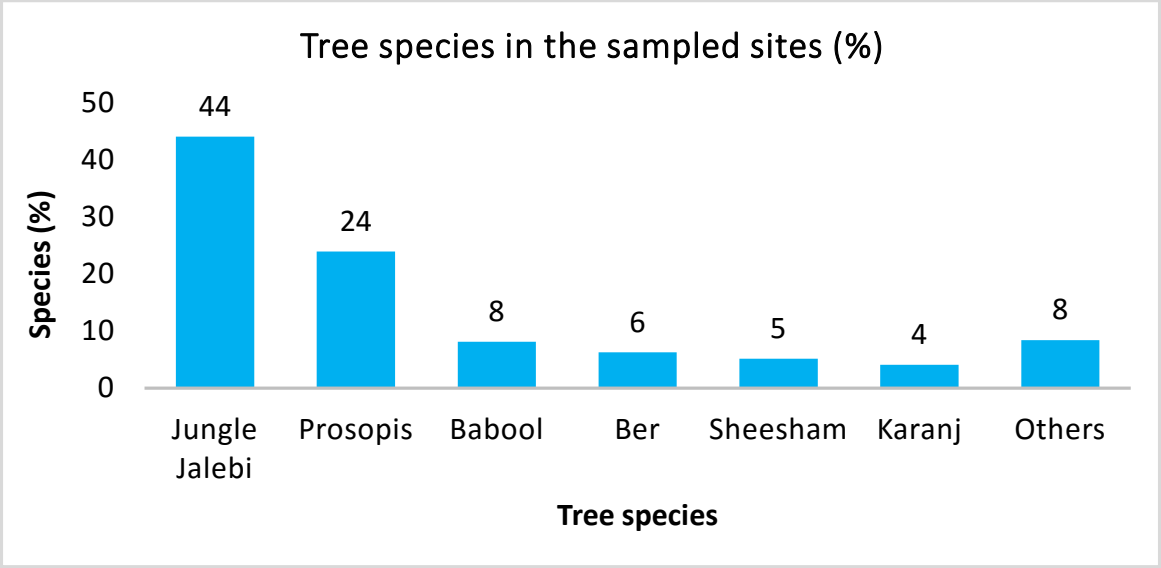

Figure 5.4: Tree species sampled in the afforestation sites of Uttar Pradesh

Most of the block plantations in the natural landscape were taken up along the banks of the Ganga. These plantations get waterlogged during the monsoon and post-monsoon. Species such as Jungle Jalebi, Arjun, Jamun etc. were planted, which can withstand the inundation. But Arjun and Jamun were found to be severely browsed by feral cattle and wild herbivores such as Nilgai and Chital. Hence, only thorny species like Jungle Jalebi, Khair and *Prosopis* survived. In the urban landscape, plantations were taken up along the roadside and in institutional areas. The main species planted were *Ficus benjamina*, Karanj, Balamkheera, Ashoka, Chitwan, Jacaranda, Molshree, Bottlebrush, Neem etc. (Box 5.2). Iron and brick tree guards were used as the main protection measures.

Box item 5.2: Successful avenue plantations in the urban landscape

The avenue plantations in the urban landscape performed very well. Most of the species planted were fast growing ornamental species (*Ficus benjamina,* Molshree, Jacaranda etc.), and some were medicinal as well (Balamkheera, Neem, Chirol, Karanj etc.).

Figure 5.5: *Prosopis juliflora*, an invasive alien species is planted extensively in the natural sites of the Ganga Khadar

5.3.2 Effectiveness

To evaluate the effectiveness of the plantations, plant survival and growth was assessed.

5.3.2.1 Plant survival

The overall survival of the plantations was found to be satisfactory (69.01 %). The avenue plantations in the urban landscape showed much better survival (91.83 %) than the plantations in natural landscape (65.70 %, Table 5.2). This was due to the use of the iron and brick tree guards as a protection measure. On the other hand, in the natural landscape plantations, the cattle proof trench was found to be ineffective. Barbed wire fencing with RCC columns was also found to be damaged in many places. Hence, the plantations in the natural landscape got impacted by feral cattle, Nilgai and Chital.

Table 5.2: Survival and growth of plants in the natural and urban landscape

Landscape	Survival %	Average height (m)	Average girth (cm)
Natural landscape	65.70	1.28	7.22
Urban landscape	91.83	5.45	35.82
Weighted average	**69.01**	**1.38**	**7.92**

Table 5.3: Growth parameters of the planted species

Species name	Average Height (m)	Average GBH (cm)
Aam	3.05	17.00
Amaltas	4.57	27.00
Amrud	5.79	38.00
Arjun	0.46	3.25
Ashoka	3.30	18.09
Babool	1.13	6.44
Bakain	1.52	3.00
Balamkheera	6.95	49.38
Bans	0.58	3.27
Ber	0.82	3.98
Bottlebrush	3.96	25.20
Chakundi	1.22	6.00
Chirol	0.81	4.14
Chitwan	4.88	41.10
Chukrasia	5.79	33.67
Eucalyptus	4.33	21.78
Ficus Benjamina	5.58	40.59
Gular	4.27	29.00
Gulmohar	5.79	45.00
Imli	4.57	39.00
Jacaranda	5.72	30.67
Jamun	2.19	11.00
Jungle Jalebi	0.98	6.18
Kachnar	6.40	32.00
Kadam	7.62	65.00
Karanj	2.26	13.84
Kat Sagaun	0.46	7.50
Kathal	5.49	38.00
Khair	1.06	6.37
Mahogany	5.49	24.67
Molshree	4.40	28.71
Neem	4.15	18.00
Pila Gulmohar	5.49	38.00
Prosopis	1.68	8.07
Sheesham	2.41	14.44
Tabebuia	6.71	38.33

5.3.2.2 Plant growth

The overall plant growth was found to be satisfactory (average height 1.38 m, average girth 7.92 cm). The growth of the planted species was found to be much higher in the plantations in the urban landscape (Table 5.2). This was due to the plantation of tall seedlings (1.5 - 2 m) protected by iron or brick tree guard. On the other hand, seedlings of less than 1 m height were planted in the natural landscape which were damaged by feral cattle, domestic cattle and wild animals due to inadequate protection provided by the cattle proof trench or barbed wire fence.

5.3.3 Sustainability

In order to strengthen the sustainability of the plantations, following measures were used.

5.3.3.1 Protection measure

Before the plantations were taken up, most of the plantations sites were used for grazing by the village cattle. The protection measures observed in the plantation sites were barbed wire fence, cattle proof trench, iron tree guard and brick tree guard. Among the above protection measures, the iron tree guard was found to be the most effective. These tree guards were used in the avenue plantations of Prayagraj division. Brick guards also provided good protection to the plants and were used in the avenue plantations of Varanasi division (Figure 5.6). But these are less durable and get damaged within a few years.

Figure 5.6: Brick and iron tree guards provided good protection in the avenue plantations of Varanasi and Prayagraj

Cattle proof trenches were constructed along the periphery of the natural block plantations of Hardoi and Badaun divisions (Figure 5.7). These trenches were filled up with the excavated soil at select places and access paths were made. Hence, these trenches were unable to keep the cattle out. The barbed wire fencing was used in the natural block plantation of Prayagraj division (Figure 5.6). But this fence was found to be damaged in multiple places, leaving the plantation unprotected. Therefore, these type of structures were found to be ineffective.

Figure 5.7: Barbed wire fence and cattle proof trench were ineffective in protecting the natural block plantations in Prayagraj and Hardoi

5.3.3.2 Watch and ward

After planting, there is a provision of 3 years' maintenance including watch and ward. This work is carried out by a chowkidar appointed by the forest department. In natural landscape one chowkidar is appointed for 10 ha of plantation and in urban landscape one for every 1000 plants.

5.4 Good practices

The planted tree species in avenue and institutional plantations of urban landscape showed excellent growth and survival. The plantation journals were well maintained with geo-referenced plantation polygon, soil test report and monitoring comments of senior officers recorded in it.

5.5 Suggestions

Overall the forestry plantations are doing well specially in the urban landscape and the following suggestions are provided to further improve the outputs and outcomes in future.

a) The plantation model for Ganga Khadar grasslands needs to be relooked

The Ganga khadar region is characterized by tall riparian grasslands. These natural grasslands stabilize the bank and also filter the runoff. FRI in its DPR has prescribed the plantation model NL/P/01 that comprises tree/shrub 625 nos., grasses/sedges 400 nos. and medicinal plants 200 nos. with an objective to convert this natural grassland into a woodland which is ecologically not desirable. Hence, till the time a deeper understanding is reached on this issue, using the precautionary principle it is recommended that woody plants (including Khair and Shisham) should not be planted in these natural grasslands of the Ganga Khadar. (Figure 5.8).

Figure 5.8: Ganga Khadar grassland, Hardoi forest division

b) Exclusion of Prosopis juliflora from plantations

Planting of Prosopis has been included in the NL/P/01 plantation model by the state forest department. This species should be excluded from this plantation model, as it is a severe invasive species which rapidly colonizes the grassland, supresses grass growth, makes the area inaccessible, and displaces native species. It also impacts the livelihoods of people as it significantly reduces availability of fodder, fruit and medicinal plants, though it provisions fuelwood. A list of exotic tree species such as *Prosopis juliflora*, *Eucalyptus* sp. and others needs to be prepared and these species excluded from future plantations.

c) Shortage of tall seedlings in the forest nurseries

Tall seedlings of native species that have attained 1.5 – 2 m height should be planted. Growing such tall seedlings in the forest nursery takes at least two years. In the state of Uttar Pradesh, a large-scale state-driven afforestation programme is underway which is also competing for nursery seedlings. In this scenario, it is difficult to source two-year-old seedlings from forest department nurseries, as they get exhausted in the first year itself (Figure 5.9). This issue needs to be addressed so that tall seedlings 1.5-2 m height that are two-year-old are only planted.

Figure 5.9: Seedlings grown in the forest nursery are planted out in the first year itself

d) Community participation was lacking

Many of the protection measures such as fencing and watch and ward did not work optimally as the community was not involved in the plantation project. The plantation sites were used by the villagers as grazing lands for their cattle. When these areas were fenced off and afforested their livelihood got adversely impacted. So in many sites it was found that the fences had been broken, the cattle proof trench had been filled up and a pathway created for

the livestock. Hence, we suggest that unless the community is involved in the plantation and they agree to safeguard it post creation it is risky to invest public money in suo moto creation of forestry plantations.

e) Cattle proof trench found to be ineffective

In the natural landscape in the Ganga Khadar, the cattle proof trench gets silted up during the monsoon floods and only serves the purpose of demarcating the plantation. The feral cow menace (*awara maveshi*) is also growing, impacting the sustainability of the plantations. Nilgai herds are browsing the plantations (Figure 5.10) and Arjun and Jamun saplings are not spared thereby adversely impacting their growth and survival. Plantations in urban areas have iron tree guard provision and are performing well. The disadvantage of perimeter based fencing approach is that even if it gets broken in one place, its total effectiveness gets compromised. However, in the case of individual tree guards, even if a few get damaged, the others will continue to serve their purpose. Similarly, in natural landscape areas facing grazing threats, suitable tree guard at the individual plant level, with lesser number of trees needs to be explored on a pilot basis. Based on the plantation performance and the financial feasibility, the decision on adopting this model for future plantations can be made.

Figure 5.10: Nilgai is one of the main threats to forestry plantations and is not easily contained by fences

f) Assigning plantation targets in consultation with the forest divisions

There is a dearth of deforested sites in the natural landscape that can be taken up for tree planting. The practice of assigning plantation targets to the forest divisions in a top-down

manner results in unsuitable sites being taken up for tree plantations. When plantation targets are assigned in a prescriptive manner, the division and range offices have no option but to take up afforestation on unsuitable sites such as grasslands, wetlands or under existing forest canopy. Many of the sites identified for afforestation in the FRI DPR may already be covered under other afforestation schemes. Hence, we suggest that instead of a top down assignment of plantation targets, these need to fixed in consultation with the forest divisions based on a real-time field assessment of the availability of deforested land suitable for tree planting.

g) Reuse of iron tree guards

Iron tree guards are especially useful in the avenue plantations taken up in the urban landscape having high human pressure as they safeguard the plants till establishment. However, these iron tree guards are expensive and not ecofriendly. In the established plantations that are more than 3 years old, the iron tree guards have served their purpose and can now be reused. The cost of reusing them (including removing, repairing, transportation and fixing in the new site) needs to be included in the cost estimate of the new plantations instead of purchasing new iron tree guards. This initiative will significantly bring down the cost of new avenue plantations, liberate the established saplings from the space constraints imposed by the iron tree guard and reduce the carbon footprint. Also, in plantations carried out in institutional areas, in many cases the campus is secured, hence the protection status may be assessed before deciding on the tree protection measure which may range across either iron, brick or no tree guard.

h) Implementing economic trees plantation model in the agriculture landscape

The riverscape in Uttar Pradesh has undergone a major transformation by humans. The landuse adjacent to the Ganga river is smallholder farming and is human dominated. The non-availability of public lands in the Ganga riverscape is one of the biggest constraints in restoring the river Ganga in Uttar Pradesh. Hence, to have impact on scale, farmlands need to be taken up for tree planting by providing an economic incentive to the farmers. In the FRI DPR the AL/P/01 plantation model (Planting of Economic Trees in Plains) has been made available for Uttar Pradesh, Bihar and Jharkhand. However, this model which is very relevant for these four states where the river Ganga flows through an agriculture dominated landscape, has not been implemented yet. It is suggested that suitable agroforestry, horticulture and bamboo plantations be taken up in the agriculture landscape of Uttar Pradesh so that a win win situation is created, wherein farmers derive economic benefit from planting trees which also creates a positive externality for the riverine ecosystem.

i) Ficus species can be included in the species mix

Ficus species such as Bargad, Peepal, Pakad, Gular etc. should be included in the plantation mix in large numbers as these species have long life and provide valuable ecosystem services. These species have been tried out in the adjacent state of Bihar and are performing well.

j) Timely release of plantation funds

In the key informant interview with the field functionaries, one issue that came up repeatedly was the need for timely release of plantation funds. This uncertainty and delay in the release of funds, affected the effectiveness of the plantation creation and its maintenance as well.

k) Delay in wage payment to the chowkidars (cattle guard)

The main strategy for protecting the plantations was by engaging chowkidars. However most of them did not receive their wages on time and often it got delayed by 6 -7 months. It is suggested that their wages be released on a timely basis. Also, it is recommended to enhance the number of chowkidars from one per 10 ha presently to one per 5 ha to ensure better plantation protection translating to higher survival and growth.

5.6 References

Agarwal, S. (2009). Angiosperm species diversity and ecological assessment of Hastinapur wildlife sanctuary, Uttar Pradesh, India, PhD Thesis, Aligarh Muslim University, Aligarh, India

Catterson, T. 2003. USAID Strategic integrated plan in the Sudan, 2003-2005. Environmental threats and opportunities assessment. USAID/REDSO/NPC and the USAID Sudan Task Force. Washington DC, USA. March 2003.

Kaur, R., Gonzales, W. L., Llambi, L. D., Soriano, P. J., Callaway, R. M., Rout, M. E., & Gallaher, T. J. (2012). Community impacts of Prosopis juliflora invasion: biogeographic and congeneric comparisons.

Lal, S. (1998). Rehabilitation of Ganga Khadar and Khola areas of western zone of UP by utilizing tall planting technique. *Indian forester*, 124(2), 99-115.

Mwangi, E., & Swallow, B. (2008). Prosopis juliflora invasion and rural livelihoods in the Lake Baringo area of Kenya. Conservation and Society, 6(2), 130-140.

Pasiecznik, N. 1999. Prosopis - Pest or Providence, Weed or Wonder Tree? European Tropical Forest Research Network Newsletter 28: 12–14.

Pasiecznik, N. M., Felker, P., Harris, P. J., Harsh, L., Cruz, G., Tewari, J. C., ... & Maldonado, L. J. (2001). The Prosopis juliflora-Prosopis pallida complex: a monograph (Vol. 172). Coventry: HDRA.

Paul, S., Saha, S., Nigam, P., Ali, S. Z., Page, N., Khan, A. S., ... & Mondol, S. (2021). Waning grasslands: a quantitative temporal evaluation of the grassland habitats across human-dominated upper Gangetic Plains, north India. *bioRxiv*.

Sudan Update (1997). Desert tree Is a victim of its own success. Sudan Update Vol. 8 No. 22, 11/97.

Chapter 6

Bihar State

6.1 Restoration context

The restoration context in Bihar is unique and faces several challenges and vulnerabilities. The main challenge observed is the scarcity of forest land along the Ganga, as the riverscape is dominated by agricultural land use. All the Ganga districts have a dearth of forest land for taking up tree plantations. Hence, the forest department is focusing on afforesting the government-owned land mostly in the urban landscape owned by line departments such as roads, irrigation, etc. As a result, the plantations in Bihar were largely taken up as roadside avenue plantations with iron and bamboo tree guards. Here there is high population density especially along the roadsides (Figure 6.1). North Bihar is affected by severe flooding and waterlogging every year during the monsoon months. The annual floods force the local people to move to the roadsides with their belongings and livestock, further increasing the pressure on roadside plantations. Skeletal staffing of forest personnel was also observed. One division spans across two to three districts and is manned by one divisional forest officer, one range forest officer, one forester and 2-3 forest guards.

Figure 6.1: Roadside plantations compete for space with high population density

6.2 Sampling design

During the three financial years of 2016-17, 2017-18, and 2018-19, a total of 86 plantation projects were funded by NMCG in the state of Bihar. A total of 23 plantation projects were implemented in the Patna forest division followed by 22 in Bhagalpur and 16 in Begusarai. A total investment of Rs. 3680.80 lakh was made during this period, with Rs. 2318.41 lakh made in Bhagalpur forest division, followed by Begusarai (Rs 418.48 lakh) and Patna (Rs. 367.96 lakh, Figure 6.2). In the first stage of sampling, forest divisions were selected based on the quantum of investment. Thus the three forest divisions having the highest investment namely Bhagalpur, Begusarai and Patna were selected for the study.

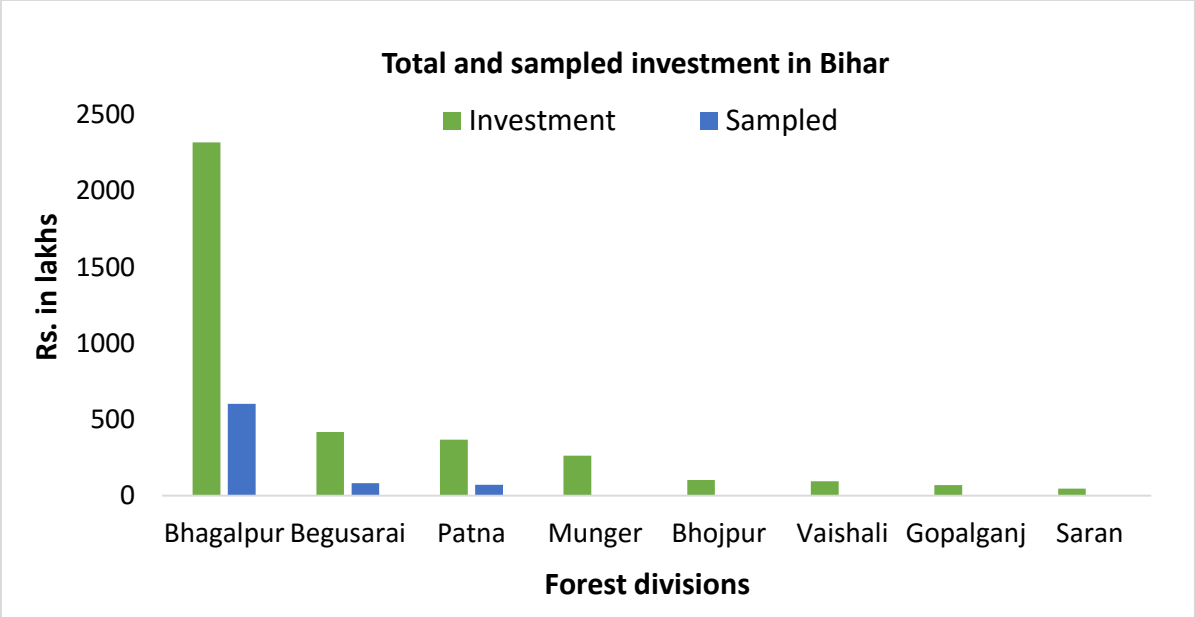

Figure 6.2: Total and sampled investment across various forest divisions of Bihar state

In the second stage of sampling, the sites were selected considering investment, landscapes and plantation models (Table 6.1). The overall investment in the Bhagalpur forest division was the highest and therefore more number of sites were sampled in this division.

Table 6.1: List of plantation sites sampled for the evaluation study

Year	Forest Division	Model No.	Site name	No. of Plants	Cost in Lakhs
2017-18	Bhagalpur	NL/P/06	Ultapul to Jagdishpur	12,000	249.20
2017-18	Bhagalpur	NL/P/06	Nathnagar to Shahkund	9,000	186.90
2016-17	Bhagalpur	NL/P/07	Raghopur To Koji Koraiya Ganga Bandh	6,000	133.19
2016-17	Bhagalpur	NL/P/10	Kastikari To Chandan Nadi Bandh	6,000	32.79
2016-17	Begusarai	NL/P/06	Godargama To Vrindavan	1,800	39.96
2016-17	Begusarai	NL/P/06	Panchvir To Bahloria	1,200	26.63

2017-18	Begusarai	NL/P/07	Sakti Chaura to Lakhminia Bazar	400	15.63
2016-17	Patna	NL/P/07	Gangapul Phunch Path, Digha	1,000	41.06
2017-18	Patna	NL/P/07	Gangapul Pahunch Path	500	19.54
2017-18	Patna	NL/P/07	Barh Thana NP to Alakhanath Ghat	300	11.73
Total					**756.63**

Three plantation models were covered during the evaluation. Model NL/P/06 is a linear mixed species plantation with 300 bamboo tree guards of size 2.1m x 0.6m x 0.6 m per hectare. Model NL/P/07 is linear mixed species plantation with 300 iron tree guards of size 1.5m x 0.6 m per hectare. The model NL/P/10 is a riverside linear mixed plantation with 500 mounds of size 2.6 m x 1.00m x 0.60m per kilometre.

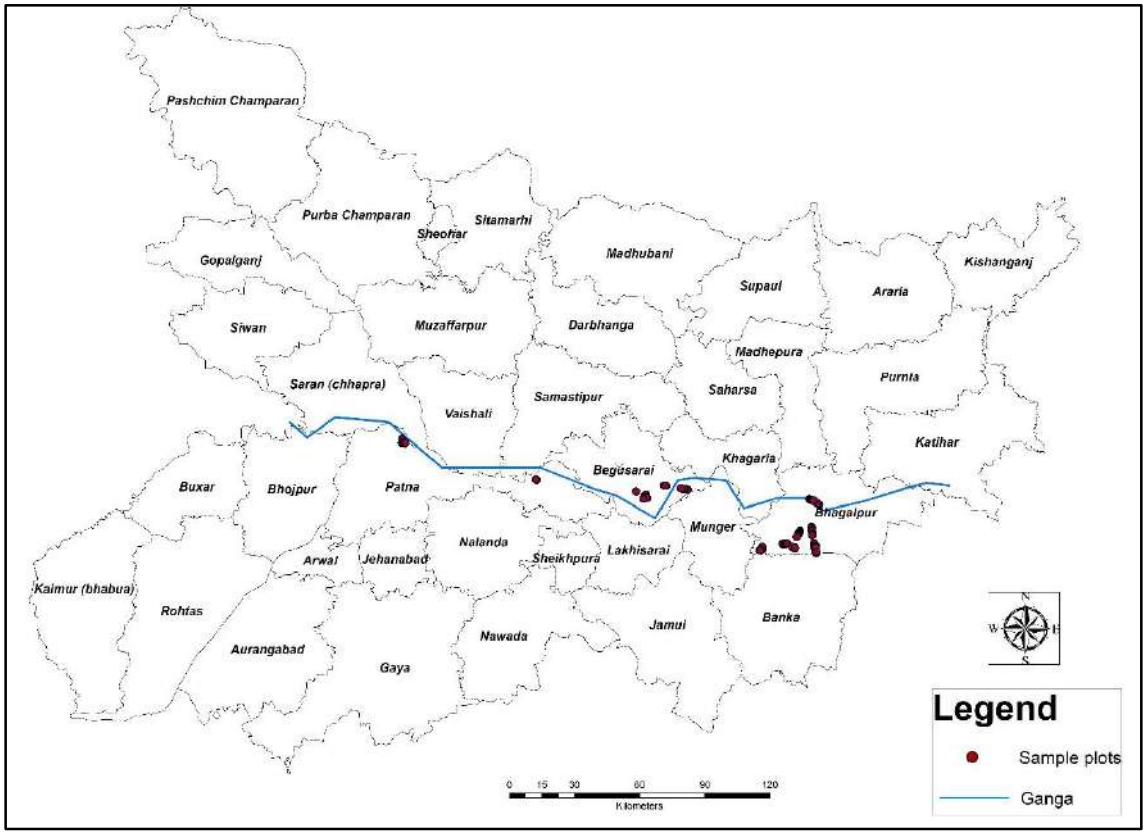

Figure 6.3: Distribution of sample plots of the evaluation study

6.3 Findings

The findings were grouped under three headings namely, relevance, effectiveness and sustainability as described below.

6.3.1 Relevance

The relevance of the plantation was assessed based on suitability of the site for tree plantations and species selection.

6.3.1.1 Site suitability

In the block plantations taken up in the natural landscape, before the plantations were taken up most of these sites were used for grazing of the village cattle. Empty mounds remained in sites where village grazing lands were taken up for afforestation as the seedlings faced high grazing pressure (Figure 6.4). In sites prone to flooding, the construction of mounds was found to be a good practice aiding in higher survival. The avenue plantations were mostly carried out in densely populated areas. It was found that the bamboo tree guards did not last for more than a year, while the plantations with iron tree guard showed better results. However, bamboo tree guards are cost effective, eco-friendly and also encourage farm forestry and sustain local livelihoods.

Figure 6.4: Saplings planted on mounds suffered casualty by grazing and waterlogging

6.3.1.2 Species suitability

Tall seedlings of Jamun and Arjun having a height of 1.5 - 2 meter (Figure 6.5) were mainly planted in waterlogged areas, while Neem was planted in sandy soils. *Ficus* species such as, Pakad, Peepal, and Gular were also planted. Predominantly native tree species such as, Jamun, Arjun, Neem, Kadam, and Aam were preferred (Figure 6.6). The 'others category' in this figure includes Drumstick (3%), Peepal (3%), Sheesham (2%), Chakundi (2%), Gulmohar (2%), Chitwan (2%) and Babool (2%). During the monsoon, most of the plantations get inundated. To ensure plantation survival, species such as Arjun, Jamun, Kadam etc. were planted, that can withstand waterlogged condition.

Figure 6.5: Tall seedlings of Arjun procured from private nurseries stocked in the forest nursery

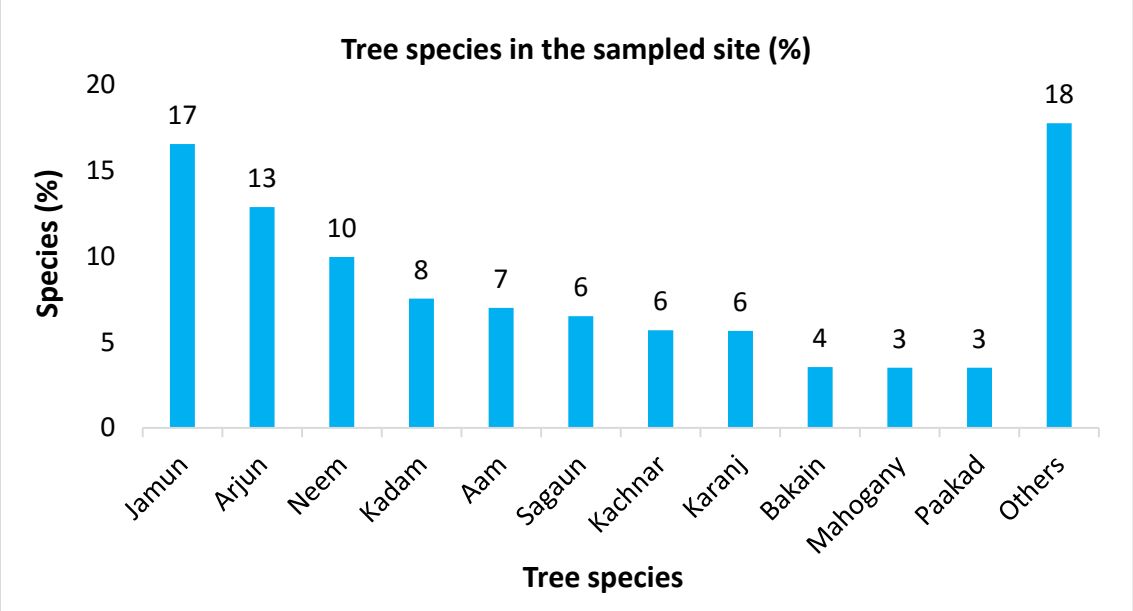

Figure 6.6: Tree species planted in the sampled sites of Bihar

6.3.2 Effectiveness

To evaluate the effectiveness of a plantation, two parameters namely, plant survival and growth were taken into account.

6.3.2.1 Plant survival

The overall survival of the plantations was found to be satisfactory (61.46%). The linear plantations showed much better survival compared to the block plantations. This was due to the use of iron or bamboo tree guard as the protection measure. But some of these plantations were carried out in densely populated areas used bamboo tree guards that did not last more than a year and therefore the plants were damaged by cattle. However, in sparsely populated areas, the plantations protected with bamboo tree guards performed well. On the other hand, the block plantations in natural landscape faced severe grazing threat as there was an absence of any physical protection measure.

6.3.2.2 Plant growth

The overall growth of the plantations was excellent and the plants attained 5.76m height and a girth of 39.23 cm in just three years. The growth of the plants in the linear plantations was found to be slightly higher (Table 6.2). This survival and growth would not have been possible without tree guards, mound planting and tall planting material.

Table 6.2: Survival and growth of plants

Survival %	Average height (m)	Average girth (cm)
61.46	5.76	39.23

Table 6.3: Growth parameters of the planted species

Species name	Average Height (m)	Average GBH (cm)
Aam	3.27	22.18
Amla	5.18	38.00
Amrud	2.74	15.00
Arjun	6.42	44.63
Babool	5.49	45.00
Baheda	8.08	42.00
Bakain	7.29	51.82
Bargad	4.88	27.33
Chakundi	7.04	50.50
Chirol	9.75	45.00
Chitwan	4.94	46.60
Drumstick	6.12	51.91
Eucalyptus	11.58	64.00
Gamhar	8.38	66.50
Gular	3.81	32.50
Gulmohar	6.93	58.33
Gunpowder tree	6.86	69.50
Jal Ghamer	2.44	13.50
Jamun	3.93	27.89
Jungle Jalebi	8.99	74.00
Kachnar	2.79	18.00
Kadam	6.72	47.04
Karanj	4.19	29.04
Kusum	4.11	29.00
Mahogany	7.76	45.67
Neem	5.05	37.78
Paakad	5.86	40.53
Peepal	7.89	72.13
Pila Gulmohar	9.14	46.00
Sagaun	8.65	38.73
Semal	7.72	39.67
Sheesham	7.36	44.33
Siris	6.10	38.00

6.3.3 Sustainability

In order to strengthen the sustainability of the plantations, following protection, adaptation and summer watering measures were used.

6.3.3.1 Protection and adaptation measures

The protection measure observed in the plantation sites was iron and bamboo tree guards. In the avenue plantations, iron tree guards were used in Patna, bamboo tree guards in Bhagalpur and both bamboo and iron tree guards in Begusarai. After planting, watch and ward is done for 3 years during the maintenance period. For this a chowkidar is appointed from the nearest village. In block plantations, one chowkidar is appointed to look after 10 ha of a plantation, while in the linear plantations, one chowkidar is appointed for every 1000 plants. In the block plantation in Bhagalpur, saplings were planted on mounds of 2.6 m x 1.00m x 0.60m size as an adaptive measure against the waterlogging condition (Figure 6.7).

Figure 6.7: Iron tree guards in linear plantations and mounds in block plantations

6.3.3.2 Watering

Plants were watered (with a tanker) every week from March to June for a period of three years. This activity ensured good survival and early establishment of the plants.

6.4 Good practices

a) **Species selection:** The species choice was suited to the local context, native species were preferred and tall seedlings were used. Prolonged waterlogging in the monsoon caused casualty of saplings. Hence, Arjun and Jamun were preferred in the low-lying flood prone areas as they can withstand waterlogging condition. Neem was planted in sandy soils (Figure 6.8), while Kadam was planted in large numbers as it is a fast-growing fruiting tree. Planting of Ficus species such as Peepal, Gular and Paakad was also encouraged.

Figure 6.8: Neem saplings established in the sandy soil along the stream banks

Figure 6.9: Tall seedlings from private nurseries kept in the forest nursery and ready for planting

b) Tall seedlings and aftercare: Tall seedlings of at least 1.5 m height were planted, and fertilizer was applied in regular intervals. The roadside plants were watered with a tanker every week for four months from March to June. This ensured higher survival and early establishment. Most of the seedlings were procured from private nurseries and stored in the forest department nurseries before planting (Figure 6.9).

c) **Mound planting** was done in the block plantations to tackle the problem of waterlogging in low lying areas (Figure 6.10). Planting species that are resilient to waterlogging such as Arjun and Jamun on mounds (nearly 1m high) is a good practice in the block plantations.

Figure 6.10: Planting of tall seedlings of Arjun on mounds in waterlogging condition

d) **Success of avenue plantations:** Tall seedlings of at least 1.5 m height were planted, and fertilizer was applied in regular intervals. The roadside plants were watered with a tanker. Despite high population pressure, the survival and growth of the seedlings was very good. Tall seedlings of native species such as Arjun, Jamun, Kadam etc. were planted. Iron and bamboo tree guards were used as protection measures, which ensured the survival of the plants. Hence, within 4 years, plants attained a height of 6 – 6.5 m (Figure 6.11).

Figure 6.11: Roadside plantations with tree guards showed excellent performance

6.5 Suggestions

Overall the forestry plantations are doing well and the following suggestions are being provided to further strengthen the outputs and outcomes of the programme in future.

a) Reuse of iron tree guard

Iron tree guards are especially useful in the avenue plantations taken up in areas having high human pressure as they safeguard the plants till establishment (Figure 6.12). However, these iron tree guards are expensive and not ecofriendly. In the established plantations that are more than 3 years old, the iron tree guards have served their purpose and can now be reused. The cost of reusing them (including removing, repairing, transportation and fixing in the new site) needs to be included in the cost estimate of the new plantations instead of purchasing new iron tree guards. This initiative will significantly bring down the cost of new avenue plantations, liberate the established saplings from the space constraints imposed by the iron tree guard (Figure 6.13) and reduce the carbon footprint. In institutional areas the protection status may be assessed before deciding on the tree protection measure which may range across either iron tree guard, bamboo tree guard or no tree guard. If the campus is secured and it is a gated community, then tree guards may not be needed at all.

Figure 6.12: Roadside plantations in the urban spaces protected with iron tree guards

Figure 6.13: The iron tree guards need to be removed and reused in new plantations

b) Implementing economic trees plantation model in the agriculture landscape

The riverscape in Bihar has undergone a major transformation by humans. The landuse adjacent to the Ganga river is smallholder farming and is human dominated. The non-availability of public lands in the Ganga riverscape is one of the biggest constraints in restoring the river Ganga in Bihar. Hence, to have impact on scale, farmlands need to be taken up for tree planting by providing an economic incentive to the farmers. In the FRI DPR the AL/P/01 plantation model (Planting of Economic Trees in Plains) has been made available for Uttar Pradesh, Bihar and Jharkhand. However, this model which is very relevant for these four states where the river Ganga flows through an agriculture dominated landscape, has not been implemented yet. It is suggested that suitable agroforestry, horticulture and bamboo plantations be taken up in the agriculture landscape of Bihar so that a win win situation is created, wherein farmers derive economic benefit from planting trees which also creates a positive externality for the riverine ecosystem.

c) Record keeping needs to be strengthened

Record-keeping was found to be inadequate in all the sampled sites. This was largely due to inadequate staffing. Now that the state has recruited frontline forest staff, it is suggested that plantation journals in the prescribed format be maintained and kept updated to enable effective monitoring and evaluation. The plantation journal needs to include a site map, soil details,

plantation polygon points, pits dug, the species-wise breakup of plants planted, breakup of a site into sectors/patches, process photos etc. Internal inspection reports of supervising officers also need to be entered into these registers. Maintaining these journals should be made a mandatory requirement and their quality checked before final payments for the works are released. Also, the geo-referenced plantation polygon of the perimeter of the plantation as a KML file (as is done in CAMPA funded plantations) should be diligently recorded and stored with the division office for future reference. This will enable better monitoring and evaluation as detailed documentation of the works is readily available.

d) The potential of Google Earth Pro needs to be harnessed

The Google Earth Pro is a free software that runs on desktop and mobile and helps import and export GIS data and also goes back in time with historical imagery function. Once the geographical location of the planting site is known, the following questions can be answered using this software:

- Status of existing vegetation on the plantation site before the plantation
- Whether plantations were carried out on this site in the past over the last 10-15 years
- The extent and quality of pit digging or mounding
- Yearly growth of the plantations

The Google Earth app can serve as a boon for senior officers as considering the number of plantation works underway, it is not possible to visit all the sites on foot. The use of this App needs to be integrated officially into the planning and monitoring of departmental plantations.

e) Difficulty in monitoring plantations with bamboo tree guards

For sampling, one needs to be aware of how many plants were planted in a particular stretch, to be able to monitor the present status. While the surviving plants can be enumerated, the challenge is in ascertaining how many plants were planted. In mound plantations, the mounds can be enumerated to figure out how many plants were planted and the surviving ones can be enumerated to assess the survival percentage and growth characteristics. Also, in the case of iron tree guard plantations, it is possible to ascertain the number of plants planted is a particular stretch, as the iron tree guards are visible and are also numbered. However, in the case of linear plantations without tree guards or with bamboo tree guards (which last for only 1-2 years) it is difficult to monitor as the evidence of plants that were planted but did not survive is not there. Surviving plants can be enumerated, but those that were planted but did not survive cannot be discerned. The difficulty in monitoring linear plantations is to ascertain how many plants were planted in a sector/segment to enable sample check. Hence, while taking up linear plantations it is important to break them up into segments, demarcate these segments on the ground and also record the total number of plants planted segment-wise. This will enable transparent monitoring and evaluation of linear plantations with bamboo tree guards.

f) Timely release of plantation funds

In the key informant interview with the field functionaries and in the state consultation, this issue came up repeatedly regarding the timely release of plantation funds. This uncertainty and delay in the release of funds, affected the effectiveness of the plantation creation and its maintenance as well.

g) Delay in wage payment to the chowkidars (cattle guards)

The main strategy for protecting the plantations was by hiring of chowkidars. However, most of the plantation chowkidars did not receive their wages in time and often it got delayed by 6 -7 months. It is suggested that their wages be released on a monthly basis so that it is possible to keep them motivated and extract work from them. Also, it is recommended to enhance the number of chowkidars from one per 10 ha presently to one per 5 ha to ensure better plantation protection translating to higher survival and growth.

Chapter 7
Jharkhand State

7.1 Restoration context

In the state of Jharkhand, Sahibganj is the only Ganga district. It is situated on the south bank of river Ganga, and borders with Bhagalpur district of Bihar in the west and Malda district of West Bengal in the east. The Gangetic alluvial soil is fertile and suitable for plant growth. The region experiences severe floods and waterlogging every year during the monsoon. When the opening of the floodgates of the Farakka barrage is delayed, water level in the flood plains rises upto 4 to 5 feet. The district has a sizable tribal population. The sites taken up for afforestation were earlier used for browsing by the goats.

7.2 Sampling design

An investment of Rs. 761.56 lakh was made in the 11 plantation projects during the three financial years of 2016-17, 2017-18, and 2018-19. Three sites (one block plantation and two linear plantations) with highest investments were selected for the study (Table 7.1). Thus the sampling covered 30% (235.82 lakhs) of the total investment.

Table 7.1: List of project sites sampled in the evaluation study

Year	Forest Division	Model No.	Site Name	No. of Plants	Cost in Lakhs
2017-18	Sahibganj	NL/P/11	Kusumghat to Rajmahal Block plantation (Multi Row with barbed wire fencing)	87,000	66.82
2017-18		NL/P/06	Bakudi to Sakrigali Linear Plantation (Railside with Bamboo Gabion)	7,000	94.48
2018-19		NL/P/06	Mirzachowki to Sakrigali Linear Plantation (Railside with Bamboo Gabion)	5,000	74.52
			Total	**99,000**	**235.82**

Two plantation models were covered during the evaluation. Model NL/P/11 is a mixed species strip plantation on 60 cm mounds having 1500 mounds per ha with barbed wire fencing.

Model NL/P/06 is a linear mixed species plantation with 300 bamboo tree guards of size 2.1m x 0.6m x 0.6 m per hectare.

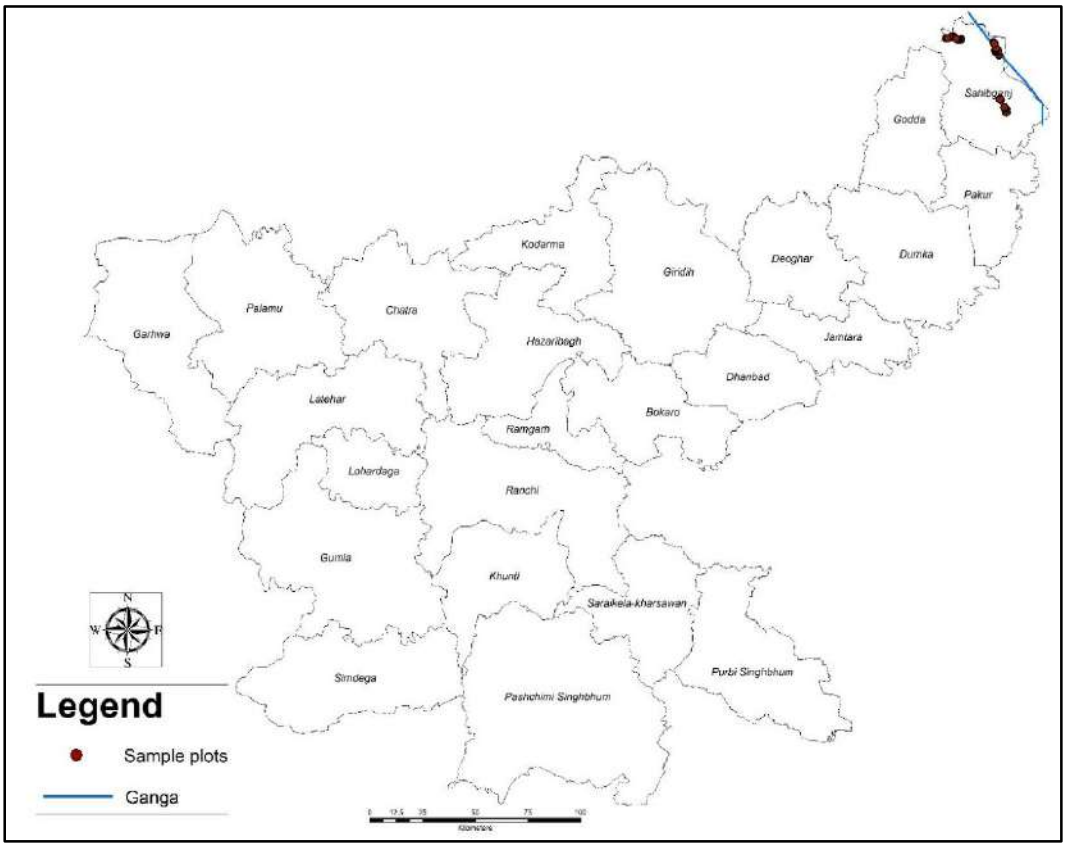

Figure 7.1: Distribution of sample plots of the evaluation study

7.3 Findings

The findings were grouped under three headings namely, relevance, effectiveness and sustainability as described below:

7.3.1 Relevance

The relevance component covered suitability of the site for tree plantations and species selection.

7.3.1.1 Site suitability

The block plantation was carried out on the stabilized right bank of the river Ganga (Figure 7.2). It is impacted by floods and waterlogging every year during monsoon. This site was earlier used by the tribal communities for paddy farming. Biotic and abiotic pressures such as grazing, browsing and forest fire were found to be low. The species such as Arjun, Jamun, Jarul etc., which can withstand waterlogging in these areas were planted. These plants have established and attained an average height of 6.57 m within 4 years. This site has now become

a suitable habitat for several species of reptiles, amphibians, birds and mammals. The linear plantations were carried out along the railway lines (Figure 7.3, Box 1) and bamboo tree guards were used for protection.

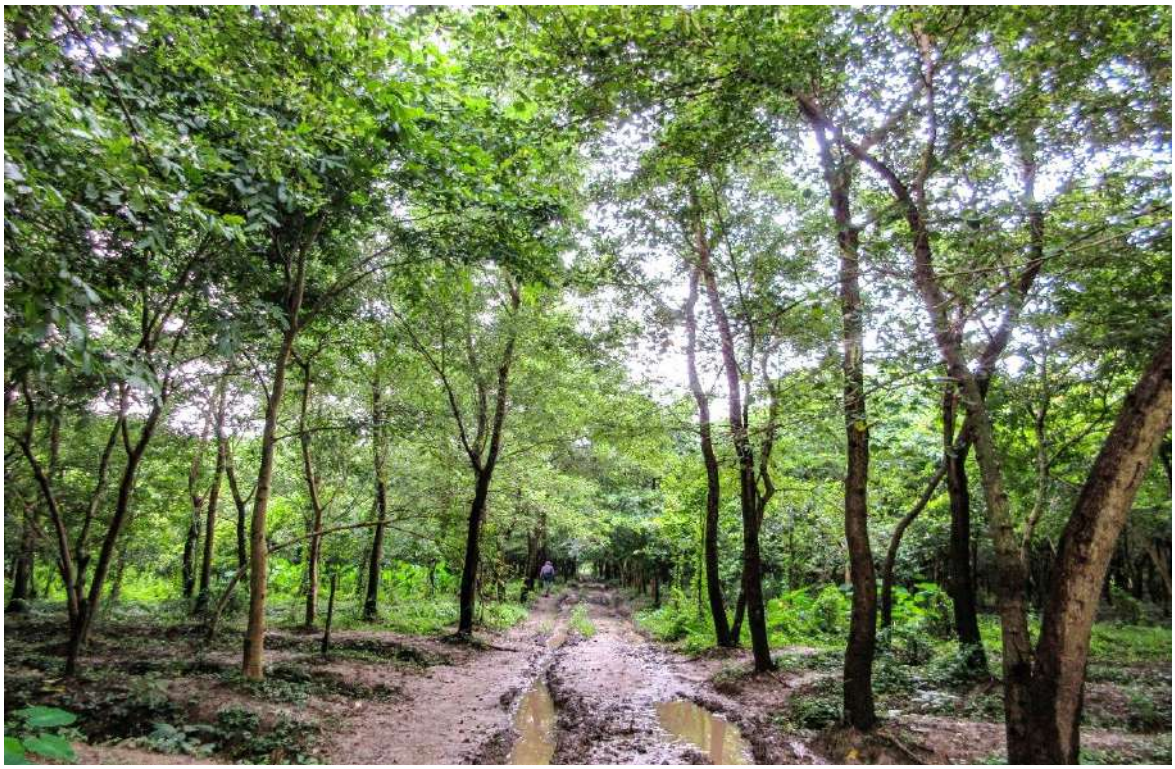

Figure 7.2: The block plantation showing excellent growth in Mehdipur, Sahibganj Division

Figure 7.3: The linear plantation with bamboo tree guards in Sahibganj Division

7.3.1.2 Species suitability

Most of the planted species were Arjun, Sheesham, Jarul, Jamun, Gulmohar, Pila Gulmohar and Mahogany etc. (Figure 7.4). The 'others category' in this figure includes Malaysian Sal (2.3%), Sagaun (1.4%), Kadam (1.2%), Siris (1%) etc.

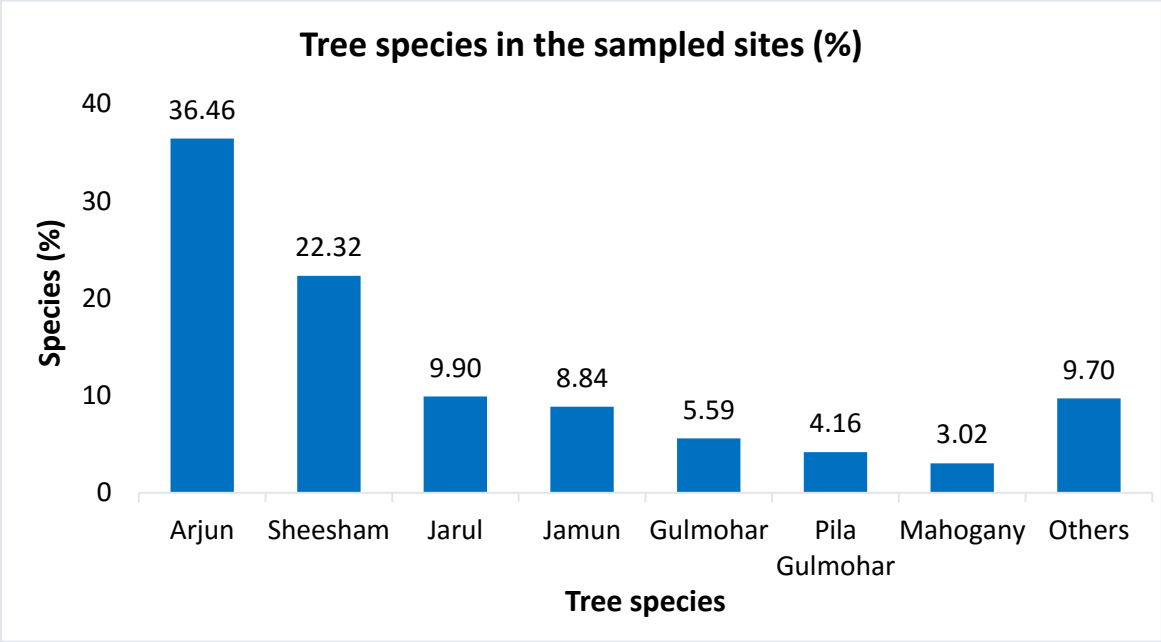

Figure 7.4: Tree species sampled in the afforestation sites of Jharkhand

In the block plantation, tall saplings (1.5 - 2 m) of flood tolerant species such as Arjun, Jamun, Jarul and Sheesham etc. were planted and attained an average height of 6.57 m in 4 years. It was also observed that after 4-5 years of planting, few Sheesham showed casualty due to pathogen attack (Figure 7.5). In the linear plantations along the railway lines, the main planted species were Gulmohar, Sheesham, Pila Gulmohar, Arjun and Sagaun. Bamboo tree guards were used as a protection measure.

7.3.2 Effectiveness

To evaluate the effectiveness of a plantation, two parameters namely plant survival and plant growth were taken into account.

7.3.2.1 Plant survival

The overall weighted survival percentage was found to be good (69.32 %). The linear plantations along the railway lines showed slightly better survival than the block plantations (Table 7.2). The survival of the block plantation was also very good. Species such as Arjun, Jamun, Jarul etc. were planted, which can withstand the waterlogging condition of this area.

Figure 7.5: Fallen Sheesham trees in the block plantation at Mehdipur

Table 7.2: Survival and growth of plants in the natural and urban landscape

Sl. No	Type of the plantation	Survival %	Average height (m)	Average girth (cm)
1	Block plantation	69.22	6.57	34.44
2	Linear plantation	72.94	5.17	30.67
Weighted average		**69.32**	**6.53**	**34.32**

7.3.2.2 Plant growth

The overall growth of the planted species was found to be excellent as plants reached an average height of 6.53 m and a girth of 34.32 cm within four years. It was slightly higher in the block plantations taken up in the natural landscape (Table 7.2). Growth parameters of the planted species is listed in Table 7.3. The multi-row planting was done on ridges with drainage provided to reduce water logging. The growth in the linear plantations was also found to be good. Tall saplings of fast growing species were planted with the protection of bamboo tree guards. In some places even after 4 years, the bamboo tree guards were found to be intact.

Table 7.3: Growth parameters of the planted species

Planted species	Height (m)	GBH (cm)
Aam	3.63	17.10
Acacia	4.48	24.43
Arjun	6.09	32.26
Babool	6.55	49.00
Bakain	5.89	43.33
Gular	6.40	58.00
Gulmohar	5.71	39.43

Jamun	3.85	18.61
Jarul	5.88	27.54
Kachnar	5.18	21.00
Kadam	6.10	35.38
Karanj	3.48	16.86
Malaysian Sal	7.20	28.43
Neem	1.98	8.00

Pila Gulmohar	5.30	29.47
Sagaun	3.91	18.31
Semal	4.48	23.86
Sheesham	7.92	45.36
Siris	8.94	51.67
Mahogany	6.31	24.47

7.3.3 Sustainability

In order to attain the sustainability of the plantations, following measures namely fencing, watering, watch and ward and people's participation was used.

7.3.3.1 Fencing

Barbed wire fencing was done in the block plantation site (Figure 7.6) and bamboo tree guards in the linear plantations along the railway lines (Figure 7.7). Both the protection measures were found to be effective.

Figure 7.6: Barbed wire fencing in Kusumghat to Rajmahal block plantation, Mehdipur

7.3.3.2 Watering

The plants were watered with a tanker in the linear plantations and using lift irrigation in the block plantation every 10 days during March to June for a period of three years. This activity ensured good survival and early establishment of the plants.

7.3.3.3 Watch and ward

The plantations are maintained for 3 years after the planting. Protection and casualty replacement are the main activities during this period. The watch and ward work is done by the chowkidar appointed by the forest department from the nearest village. One chowkidar is appointed for 10 ha of plantation in block plantations and for every 1000 plants in linear plantations.

Figure 7.7: Plantation chowkidar were engaged for watch and ward of the plantation

7.3.3.4 People's participation

In the block plantation site in the natural landscape, the support of the Ganga Prahari's was taken to gain entry into the village and short term as well as long term economic incentives were planned to mobilize the local community. Short term benefits such as wage employment, permitting intercropping of pulses in select areas, permitting cut and carry fodder collection were promised and provided while long term livelihood benefits from Tasar farming on the Arjun crop in partnership with the silk board has been promised once the trees establish after ten years. Strong participation specially of women was observed in this site.

7.4 Good Practices

7.4.1 Establishment of riverine forest at Mehdipur

This Mehdipur site was government owned revenue land and was used for farming by the local people who were mainly Santhals and immigrants. They used to grow three crops,

maize, paddy, and pulses in these farms. With the support of the Ganga Prahari's, the state forest department made the village entry and negotiation was carried out with the local community to forego farming and both short and long term benefits were promised. In the short term they were promised and provided wage employment, permission for intercropping of pulses in select locations and permission to cut and carry fodder. In the long run, their village and farms would be protected from river bank erosion with the possibility of additional incomes from sericulture by Tasar farming on the Arjun trees once they establish after ten years. Arjun (*Terminalia arjuna*) is the main food plant of the Tasar silkworm which is used for making Tasar silk.

Initially, the villages were unwilling to leave their farms and forego multi-cropping, but with continuous persuasion most of them agreed. In 2017, the plantations were taken up in the lands of the families that had vacated voluntarily. In the second year for the minority who were not relenting, forceful eviction was done. In the Mehdipur block plantation a total of 261,000 saplings were planted across 174 ha along the banks of Ganga. Tall saplings (1.5 - 2 m) of native species such as Arjun, Sheesham, Jamun, Jarul, Siris, Mahogany etc. were planted on 1 m high and 1.5 m wide bunds and DAP and Urea fertilizer was applied. For proper drainage and to retain soil moisture, 1.2 m × 1.2 m trenches were dug between the ridges (Figure 7.8). This was done so as that the seedlings survive inundation when the flood waters rise upto 1- 1.5 m. Flood tolerant species such as Arjun, Jamun and Jarul were planted. The seedlings for the plantation were sourced from private nurseries.

Figure 7.8: The block plantation at Mehdipur, Sahibganj district

Figure 7.9: Google earth historical imagery shows the changes in the riverine landscape over 5 years between 2016-2022

Barbed wire fencing constructed using RCC pillars was used as the protection measure, which was found to be very effective. Watering was done regularly during the summer months using lift irrigation. Plantation chowkidars were engaged from the nearest village for watch and ward. The plants established within 4 years having a survival percentage of 69.22% and have already attained an average height of 6.57 m and girth of 34.44 cm. This riparian plantation has now developed a closed canopy and has become a biodiversity haven as it provides a suitable habitat for several species of reptiles, amphibians, birds and mammals. As a result, these animals, have found a refuge in this man made riverine forest. The significant change in the landscape between 2016 and 2022 can be observed in the Google Earth's historical imagery (Figure 7.9). Strong monitoring of this work was done by taking up videography and drone footage as well. External evaluation was also carried out by the Institute of Forest Productivity, Ranchi.

7.5 Suggestions

Overall the performance of the plantations is excellent, and the following suggestions are being provided to further strengthen the outputs and outcomes of the programme in future.

a) Mortality of Sheesham in waterlogged areas needs to be studied

Sheesham was the second most preferred species and comprised 22% of the total plants planted and is chosen since it is a pioneer species in the riverine areas. It was planted extensively in the block plantation site, where some trees had died possibly due to pathogen attack. We suggest that a study be conducted to identify the cause of Sheesham mortality and remedial measures taken accordingly.

b) Ficus species can be included in the species mix

Ficus species such as Bargad, Peepal, Pakad, Gular etc. should be included in the plantation mix in large numbers as these species have long life and provide valuable ecosystem services. These species have been tried out in the adjacent state of Bihar and are performing well.

c) Timely release of plantation funds

In the key informant interview with the field functionaries and in the state consultation, this issue came up repeatedly regarding the timely release of plantation funds. This uncertainty and delay in the release of funds, affected the effectiveness of the plantation creation and its maintenance as well.

d) Implementing economic trees plantation model in the agriculture landscape

The riverscape in Jharkhand has undergone a major transformation by humans. The landuse adjacent to the Ganga river is smallholder farming and is human dominated. The non-

availability of public lands in the Ganga riverscape is one of the biggest constraints in restoring the river Ganga in Jharkhand. Hence, to have impact on scale, farmlands need to be taken up for tree planting by providing an economic incentive to the farmers. In the FRI DPR the AL/P/01 plantation model (Planting of Economic Trees in Plains) has been made available for Uttar Pradesh, Bihar and Jharkhand. However, this model which is very relevant for these four states where the river Ganga flows through an agriculture dominated landscape, has not been implemented yet. It is suggested that suitable agroforestry, horticulture and bamboo plantations be taken up in the agriculture landscape of Jharkhand so that a win-win situation is created, wherein tribal farmers derive economic benefit from planting trees which also creates a positive externality for the riverine ecosystem.

e) Difficulty in monitoring linear plantations

In the absence of baseline information, it is very difficult to assess the performance of the plantation. For sampling, one needs to be aware of how many plants were planted in a particular stretch, to be able to monitor the present status. The difficulty in monitoring linear plantations is to ascertain how many plants were planted in a sector/segment to enable sample check. Hence, while taking up linear plantations, they should be broken up into segments, demarcate these segments on the ground and also record the total number of plants planted segment-wise. This will enable transparent monitoring and evaluation of linear plantations with bamboo tree guards.

f) Record keeping needs to be strengthened

Record-keeping was found to be inadequate in all the sampled sites. Plantation journals in the prescribed format should be maintained and kept updated to enable effective monitoring and evaluation. The plantation journal needs to include a site map, soil details, plantation polygon points, pits dug, the species-wise breakup of plants planted, breakup of a site into sectors/patches, process photos etc. Internal inspection reports of supervising officers also need to be entered into these registers. Maintaining these journals should be made a mandatory requirement and their quality checked before final payments for the works are released.

g) Delay in wage payment to the chowkidars (cattle guard)

Most of the plantation chowkidars did not receive their wages in time and often it got delayed by 6-7 months. It is suggested that their wages be released on a monthly basis so that it is possible to keep them motivated. Also, it is recommended to increase the number of chowkidars from one per 10 ha presently to one per 5 ha to ensure better plantation protection translating to higher survival and growth.

Chapter 8
West Bengal State

8.1 Restoration context

West Bengal is a biodiversity rich state with diverse physical features. The central and southern part comprise of alluvial plains of the Ganga together with its deltas, a small portion of the Sub-Himalayan region lies towards the north, while the western part has undulating topography with numerous residual hills of the Chhotanagpur plateau.[21] The eastern portion is of alluvial formation while the western part where the major portion of the study is located has red lateritic soil.[22] It experiences relatively dry and extreme weather conditions compared to other parts of the State.[23] The annual rainfall ranges from 110-150 cm with occasional droughts.[24] The Kangsabati, Damodar and Shilabati (tributaries of the Ganga) rivers are seasonal in nature and have maximum flow in the monsoon but dry up in summer. Excess rainfall raises the level of water in the reservoirs and when released, large areas get flooded. Poor moisture retention capacity of the soil and the undulating terrain leads to high runoff and soil loss. Soil infertility and limiting soil depth also pose problems. The tropical dry deciduous forests are dominated by Sal (*Shorea robusta*). The forest fringe areas are inhabited by tribes like Santhals, Kurmis, Singh sardar, Saba and Mura. The infertile soil along with inadequate irrigation facilities restricts multi-cropping and hence these indigenous communities depend on forests for supplementing their livelihoods. Urban plantations are impacted by widening of roads, intrusions like putting up hoardings and display boards and creating new infrastructure. Plantations also get adversely affected by cyclones that uproot and damage thousands of trees.

8.2 Sampling design

During the three financial years of 2016-17, 2017-18 and 2018-19, a total of 70 plantation projects were funded by NMCG in 23 forest divisions of the state (Figure 8.1). A total investment of Rs. 1152.18 lakh was made during this period. Sample sites were identified based on the landscape (natural and urban) and the quantum of investment. Thus six sample sites, three each in the natural and urban landscape which had the highest investment were

[21] WB Forest Department, 2011
[22] Forest type of WB, 2019
[23] Mishra, 2012
[24] Bhattacharya, 1985

selected (Table 8.1, Figure 8.2). Thus we covered 20.89% (240.68 lakh) of the total investment made.

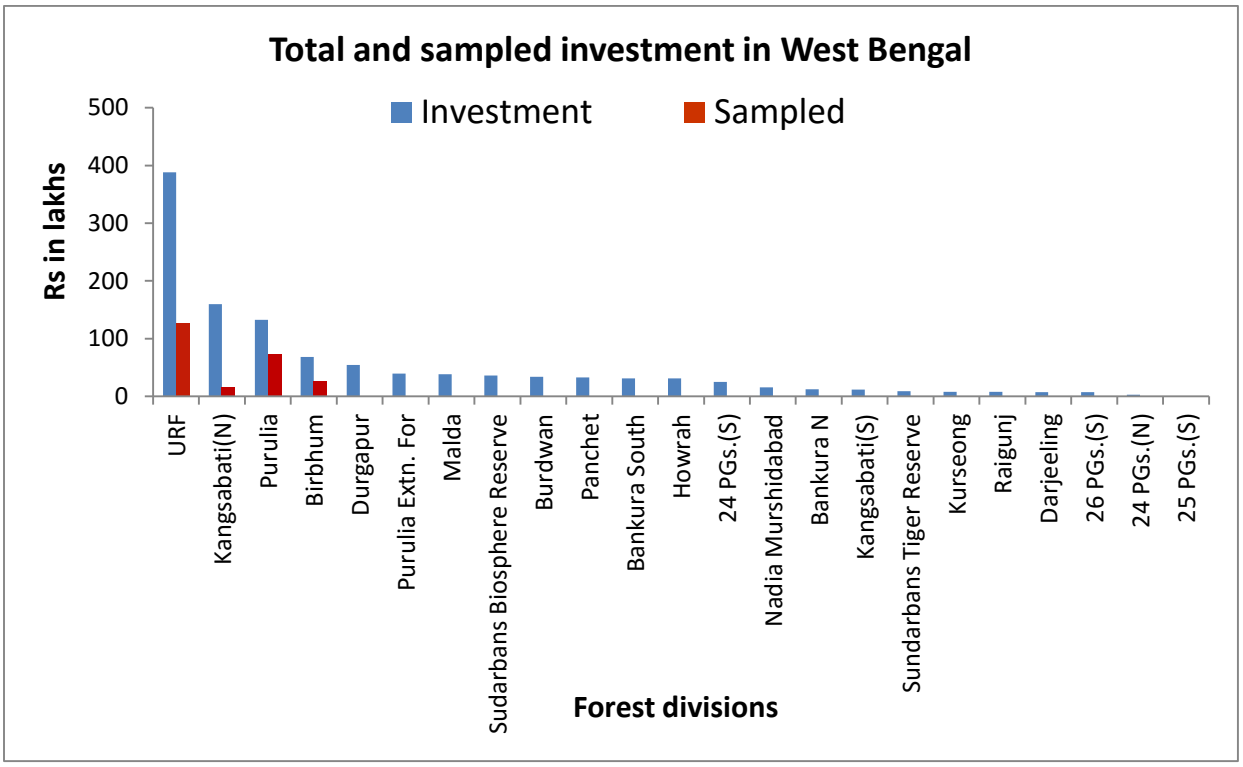

Figure 8.1: The forest divisions of URF, Purulia, Birbhum and Kangsabati (N) were selected for the study

Four plantation models were covered during the evaluation namely NL/P/13, UL/A/01 and UL/I/01. The Quick Growing Species (QGS) model - NL/P/13 was implemented in Purulia, Kangsabati and Birbhum divisions. In the UL/A/01 and UL/I/01 avenue and institutional plantation models, fast growing, wind-firm and deep rooted trees with dense foliage were planted.

Table 8.1: List of project sites sampled for the evaluation study

Year	Forest Division	Model No.	Project Name	No. of Plants	Cost in Lakhs
2017-18	Kangsabati (N)	NL/P/13	Quick Growing Species	49,600	15.15
2018-19	Purulia	NL/P/13	Quick Growing Species	77,040	30.20
2018-19	Purulia	UL/A/01	Avenue Plantation	8,200	43.45
2018-19	Birbhum	NL/P/13	Quick Growing Species	56,000	25.42
2017-18	URF	UL/I/01	Institutional Plantation	54,672	61.21
2018-19	URF	UL/A/01	Avenue Plantation	17,800	65.25
				Total	**240.68**

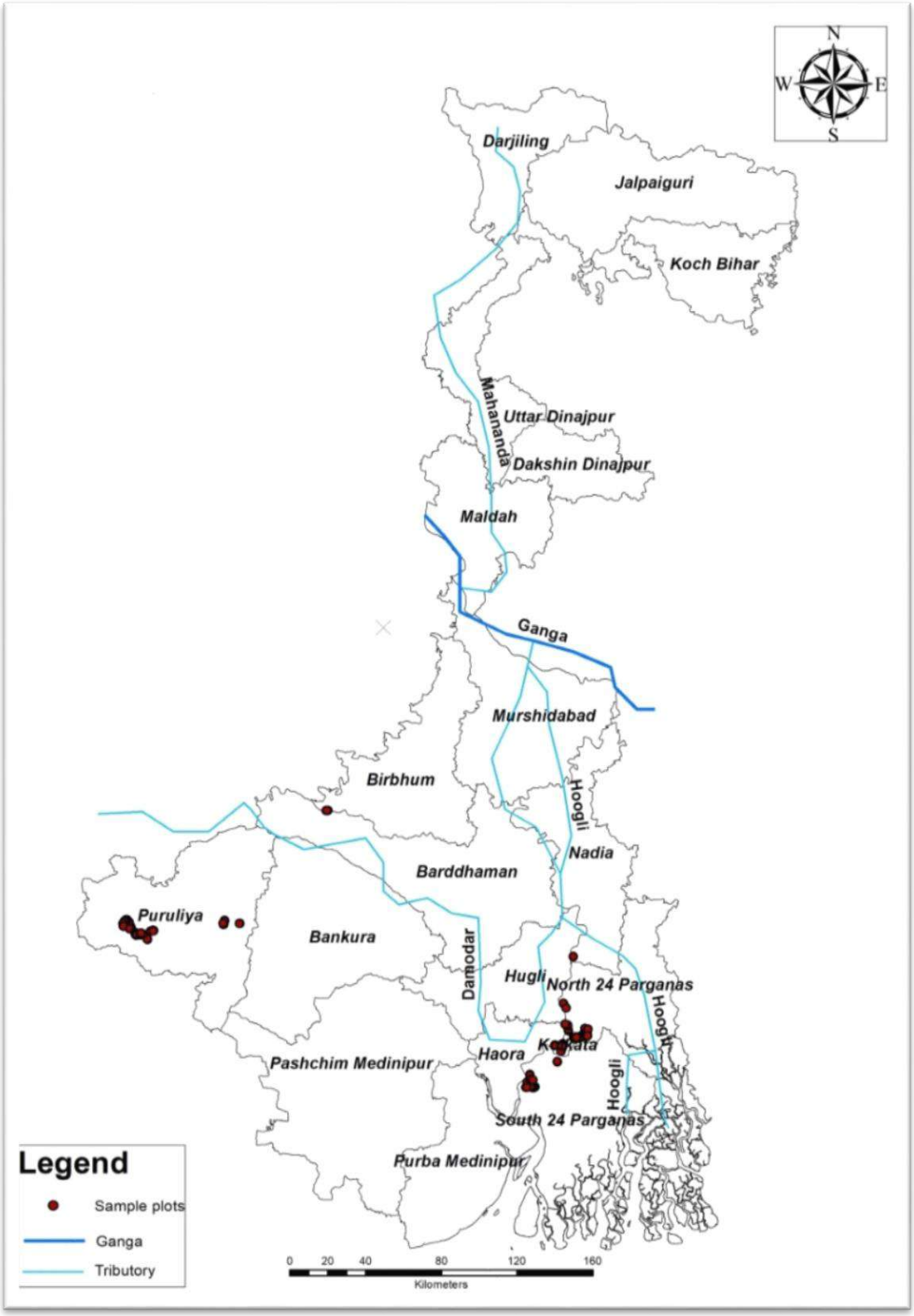

Figure 8.2: Distribution of the sample plots in the evaluation study

8.3 Findings

The findings were grouped under three categories namely relevance, effectiveness and sustainability as described below:

8.3.1 Relevance

The relevance component covered site and species suitability as detailed below:

8.3.1.1 Site suitability

The plantations in the natural landscape were taken up in the south-western part of the state which is a part of Chhotanagpur plateau. The sampled sites were mainly rugged, undulating and hilly in nature. Site selection was suitable as open and degraded forests were identified. These sites also lie within 5 km of the Ganga and its tributaries - Kangsabati, Shilabati, and Damodar that flow near the sites. One of the plantation sites lies along the bank of River Ajay experiences frequent inundation resulting in waterlogging during the monsoon months (Figure 8.3). Also, in Purulia forest division, avenue plantations were taken up along a road that passed through dense Sal forests. Tribal people were found to inhabit adjacent to the plantations. Active local participation of the Forest Protection Committee (FPC) was observed that made the plantation a success. Threats from livestock grazing and wild animals were found to be low.

Figure 8.3: Block plantation done along the banks of River Ajay in Birbhum division

Site selection for the urban landscape plantations was also suitable. Institutional plantation was done in the periphery of colleges and schools, in the water treatment plant along the

ridges of the water body (Figure 8.4) and in the Central Park (Figure 8.5). Roadside plantations were done in single, double and a triple row. Some of the roadside plantations were affected by construction activities like road widening, auto stands etc. (Figure 8.6).

Figure 8.4: Institutional plantation in water treatment plant in Kolkata, URF division

Figure 8.5: Institutional plantation in Eden garden, Kolkata, URF division

Figure 8.6: Construction of auto stands and erecting hoardings in between the roadside plantations in URF division

8.3.1.2 Species suitability

Species such as Akashmoni (*Acacia auriculiformis)*, Sheesham, Jarul, Jamun, Mahogany, Ashoka and Siris were preferred (Figure 8.7). Growth of Akashmoni was high as compared to other species. 'Others category' species were Karanj (2.97%), Amla (2.86%), Neem (2.47%), Aam (2.35%), Chitwan (2.09%), Arjun (1.86%), Amaltas (1.77%), Semal (1.58%) etc.

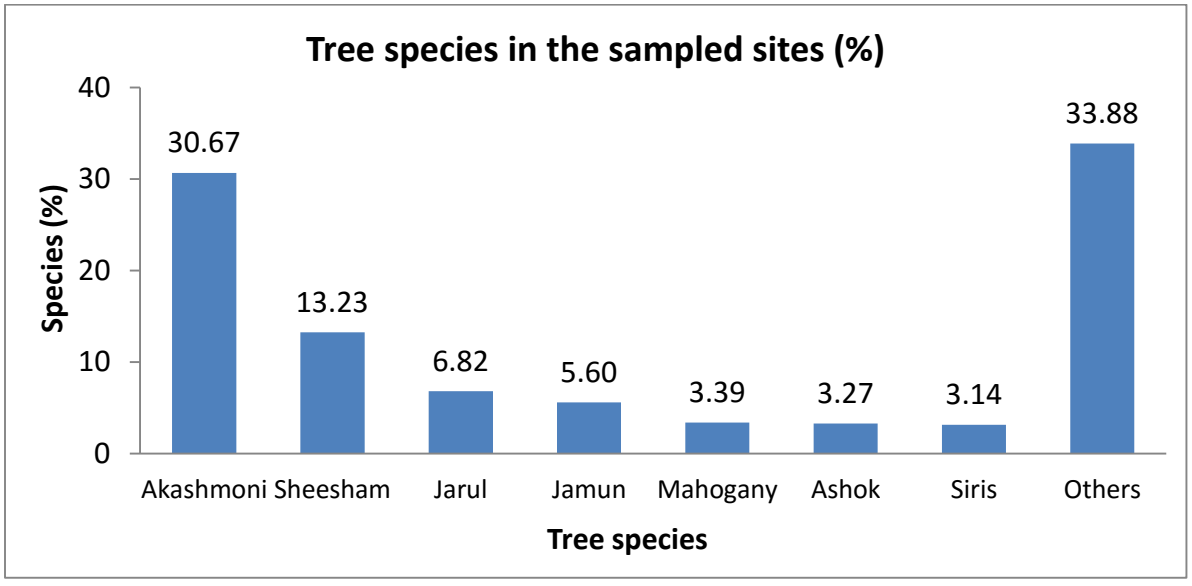

Figure 8.7: Tree species sampled in the afforestation sites of West Bengal

In the natural landscape native species like Sheesham, Jamun, Jarul, Siris, Amla and Semal were planted. Exotic species such as Akashmoni and Rudrapalash were also preferred (Box 8.1). The plantation on the banks of the River Ajay gets waterlogged during the monsoon and post-monsoon. Here, species such as Sheesham, Jamun, Arjun, Karanj, Chitwan were planted,

which can withstand the waterlogged condition for months. Sheesham was found to be the most effective in such areas (Figure 8.8). Left unprotected, species such as Arjun, Jamun and Jarul were subjected to browsing and trampling by livestock (goats, cows) in the avenue plantation sites close to the village. The natural landscape plantations were protected by cattle proof trench and live hedges like Ipomoea. In the urban plantations, a total of 65 ornamentals and fruit-bearing species were planted. The main species planted were Amrud, Aam, Bakul, Chitwan, Gamhar, Imli, Jarul, Kachnar, Kadam, Kathal, Lambu, Lichi, Putrajeeva, Semal, Siris, Sagaun etc.

Figure 8.8: Survived Sheesham plants after floods along the banks of River Ajay in Birbhum division

Box 8.1: Monoculture of Akashmoni plantations in forest land of Purulia division

Akashmoni *(Acacia auriculiformis)* is widely introduced in the natural landscape as a commercial species to meet the demands of firewood, construction material, furniture etc. This species has been planted in Purulia over an extensive area owing to its ability to grow in poor soil. But this species is an exotic and harmful to environment in reducing soil nutrients, soil moisture soil fertility, atmospheric moisture and undergrowth.[25] According to the forest department, the species was chosen as it is hardy and ideal for arid areas. People's acceptance was also important. The Forest Protection Committee (FPC) was consulted and the species was selected based on future benefit sharing from timber. Villagers have been promised 40% of the share from felling after 12 years. Villagers collect fallen dry leaves of Akashmoni for fuel (Figure 8.9). It not only saved them from the ordeal of walking long distances but also reduced their out of pocket expenses on buying fuel wood.

[25] Mahato and Jana, 2021

Figure 8.9: Tribal women collecting the dry fallen leaves of Akashmoni for fuel

8.3.2 Effectiveness

The effectiveness was measured in terms of survival and growth of the plants.

8.3.2.1 Plant survival

The overall survival of the plantations was found to be good (73.63 %). The average survival of the urban and natural landscape plantations was 74.20 % and 73.46 % respectively (Table 8.2). Urban plantations done in institutions and parks were within the institutional boundary and hence protected from biotic disturbances (Figure 8.10). Roadside plantations were protected using bamboo tree guards from the biotic pressure owing to high population density. (Figure 8.11). Natural landscape plantations lie in less disturbed forest areas. However, the soil is infertile, unproductive and erosion prone, lacks soil nutrients and water holding capacity. Despite such adverse conditions, the plants in the natural landscape performed well and showed good survival rate. Plantations were protected with cattle proof trenches and hedges. Active local participation of the Forest Protection Committee (FPC) was another reason for the good survival of the plants.

Table 8.2: Survival and growth of plants in the urban and natural landscape

Sl. No	Landscape	No. of species planted	Survival %	Average height (m)	Average girth (cm)
1	Urban	65	74.20	3.18	14.85
2	Natural	30	73.46	3.82	16.22
Weighted average			**73.63**	**3.56**	**15.66**

Figure 8.10: Linear plantations protected by bamboo tree guards, Salt Lake, URF division

Figure 8.11: Institutional plantation done in Kolkata South Range, URF division

8.3.2.2 Plant growth

The growth of the plantation was assessed by measuring the height and girth. Overall the height and girth was found to be 3.56 m and 15.66 cm respectively which is satisfactory. Average height and girth of the urban landscape plantations was 3.18 m and 14.85 cm and that of the natural landscape plantations 3.82 m and 16.22 cm (Table 8.2). Despite the poor soil quality in the natural plantation sites, the growth of the plants was found to be satisfactory. The main reason behind high plant growth in the natural plantations was Akashmoni (*Acacia auriculiformis)* which was planted in Purulia division. Akashmoni is an

exotic fast growing species that attains 15 to 30 m height in favorable conditions and 6 to 20m height in adverse conditions, with trunk diameter up to 60 cm.[26] Soil and moisture conservation (SMC) measures had also been taken up in the natural plantations resulting in better growth. Cyclones like Amphan and Yas badly affected the trees in urban areas and consequently casualty replacement had to be carried out.

Table 8.3: Growth parameters of the planted species in the sampled sites

Species	Average of Height (m)	Average of GBH (cm)
Aakando	2.13	11.00
Aam	2.26	11.55
Akashmoni	5.22	20.37
Amaltas	1.52	7.30
Amla	3.10	12.33
Amrud	2.33	10.26
Arjun	3.75	17.85
Ashoka	2.03	9.35
Babool	0.91	3.00
Baheda	2.22	10.29
Bakul	4.90	21.79
Bargad	1.52	9.00
Bael	0.61	3.00
Ber	2.44	14.00
Betel nut	2.03	10.67
Box Badam	3.90	17.40
Chakalta	2.37	10.33
Champa	2.13	9.00
Chikrashi	0.71	2.67
Chiku	1.30	6.75
Chirol	1.13	6.12
Chitwan	1.60	8.61
Christmas tree	3.20	15.50
Croton	2.13	12.83
Doka	1.68	8.50
Dreacena	1.37	6.50
Drumstick	1.22	14.00
Dumar	2.13	9.50
Edica palm	2.44	4.00
Gamhar	4.53	18.30
Gulmohar	2.46	11.76
Imli	2.64	11.67
Jacaranda	2.32	9.13
Jamrul	2.97	14.17
Jamun	1.68	10.85
Jarul	3.18	15.56
Jhau	4.11	16.00
Jungle Jalebi	4.18	17.80
Kaat Badam	3.17	15.15
Kachnar	3.00	16.00
Kadam	4.25	23.40
Kaju	2.21	17.75
Kamini	1.46	5.29
Karanj	2.39	11.46
Kathal	3.90	16.95
Korobi	2.29	15.00
Kurchi	1.98	9.00
Lambu	5.59	26.13
Litchi	1.52	3.00
Mahogany	4.77	19.52
Mahua	2.24	10.11
Mat tea	1.52	9.00
Minjiri	5.03	19.40
Murga	3.35	10.00
Mussaenda	3.35	14.00
Nag Champa	2.02	8.50
Narial	2.87	22.08
Neem	1.77	7.87
Palash	4.27	26.00
Peepal	4.57	30.00

[26] Das, 1986

Pila Gulmohar	2.34	11.00
Piyal	2.13	9.00
Plumeria alba	1.96	11.44
Putrajeeva	3.50	15.40
Raffix palm	1.22	6.00
Rain tree	2.04	9.10
Rudrapalash	3.86	18.39
Sagaun	5.85	26.80

Semal	3.40	15.44
Sheesham	3.72	17.36
Siris	3.56	15.56
Subabool	3.66	14.00
Tabebuia	2.27	9.09
Tecoma	3.05	13.00
Thespesia	2.74	25.67

8.3.3 Sustainability

In order to ensure sustainability of the plantations, protection measures and soil and moisture conservation works were carried out.

8.3.3.1 Protection measures

The protection measures observed in the natural and urban plantations were fencing (cattle proof trenches, bamboo tree guards, nylon nets, and live hedges like Ipomoea etc.), watch and ward and community participation. Cattle proof trench (CPT) were constructed along the periphery of the natural block plantations and was found to be effective but the extent provisioned was only 50m/hectare in the plan (Figure 8.12). The CPTs got silted up during the rainy season and hence their effectiveness declined after a few years. Bamboo guards were used in linear plantations but were not found to be durable due to pest attack and were also sometimes removed by the locals for firewood. Hedges made of Ipomoea around the plantation also did not last long. Nylon nets for protection of plants were used in the linear plantation in Purulia division (Figure 8.13). Watchers played an important role in protection of the plantations against livestock grazing, forest fire etc. The tribals living near the plantation sites also actively contributed in making the restoration program a success.

Figure 8.12: Cattle proof trench made to protect the site from livestock grazing

Figure 8.13: Nylon net based tree guards in linear urban plantations

8.3.3.2 Soil and water conservation measures

For soil and water conservation measures, the following initiatives were taken up:

a) Box and contour trenches

The natural landscape plantation taken up in Kangsabati division lies in water deficit area having poor soil and moisture holding capacity. There was a provision of watering using tankers but for only once or twice a month during summer. To deal with the dry season, 1.5 m deep trenches were dug in 11 ha of land. These trenches are called box trenches and were dug between every two plants (Figure 8.14). These trenches helped in storing rainwater and contour trenches were also dug to increase groundwater recharge.

Figure 8.14: Box trenches enhance soil moisture in the forestry plantations, Kangsabati division

b) Rock check dam

Rock check dams were constructed in Karma site of Purulia division (Figure 8.15) to help protect the forest land, and preserve the landscape. These structures served to reduce the runoff velocity and increase infiltration for groundwater recharge.

Figure 8.15: Rock check dam constructed in plantation site in Purulia division

8.4 Good practices

The good practices observed were suitable site selection, mixed species selection, active participation of the local community and detailed record keeping.

a) Suitable site selection

The site selected for plantation comprised of open and degraded forests, was free from encroachment and suitable for plantation. The area comprised of scattered forest growth with few native species. It was therefore easy to take up large scale block plantations in such areas. The department selected these sites to rehabilitate the degraded forests through plantation of suitable indigenous species. The plantations will further reduce soil erosion and improve the soil-moisture regime and also recharge ground water.

b) Mixed species selection

Diverse native species were raised in the forest department nurseries for the plantation. These species were better adapted to the locality and also suited the needs of the local community. In case of block plantations, fast-growing, native species with high productivity were preferred. There were fruit bearing species like Mahua, Jamun, Ber, Baheda, Sheesham, Neem, Amla, and Karanj (Figure 8.16). In the urban landscape, ornamental, shade bearing, tall trees were planted. As many as 65 different tree species were planted in urban

plantations most of which were native. Tall and sturdy trees like Ashoka and Neem were selected for the roadside plantations as they are resilient against strong winds.

Figure 8.16: Mahua saplings in forest nursery of Birbhum division

c) Soil and moisture conservation works in the natural landscape plantations

In the natural landscape, soil and moisture conservation works such as box and contour trenches, rock check dams etc. were constructed which proved to be very useful in this water deficit region.

d) Active local participation

In the natural landscape, there was active participation of the Forest Protection Committee (FPC) comprising of tribals (mainly Santhals) residing adjacent to the plantation sites. The villagers showed keen interest in the afforestation program and were involved in all stages of the program from species selection to pit digging to planting and subsequent maintenance. Active local participation ensured need based species selection and joint protection of the plantations.

e) Well maintained and detailed record keeping

The record keeping was found to be well maintained in all the sampled sites. The estimates, plantation journals, photographs, and georeferenced plantation polygons were readily available making it easier for the evaluation team to ascertain the activities and conduct the evaluation. Well maintained photographic documentation of the input, process, output and outcomes was regularly maintained and available in the division office. The plantation journal

records included a site map, soil details, plantation polygon points, pits dug, species-wise breakup of plants planted, breakup of a site into sectors/patches, process photos etc. Also, georeferenced plantation polygon of the perimeter of the plantation as a KML file is available for ready reference. Internal inspection reports of supervising officers were also entered in these registers. Plantation journals were maintained regularly to facilitate monitoring and evaluation of the projects.

8.5 Pitfalls

a) Exotic species selected in natural landscape plantation

Akashmoni *(Acacia auriculiformis),* an exotic species has been included in the NL/P/16 plantation model by the state forest department (Figure 8.17). This fast growing and hardy species has been introduced to meet the demands of firewood, timber etc. However, it is reported that this species has negative effects on biodiversity, soil health and water availability.[27] It results in a decline in soil moisture and rapid rise in temperature, which significantly affect soil macrofauna. It also adversely impacts existing native species.[28] In water deficit regions, planting exotic *Acacia* in a large scale may also alter the water availability pattern as it consumes more water than other native species. [29]

[27] Mahato & Jana, 2021
[28] Mallick, 2019
[29] Mahato 2021

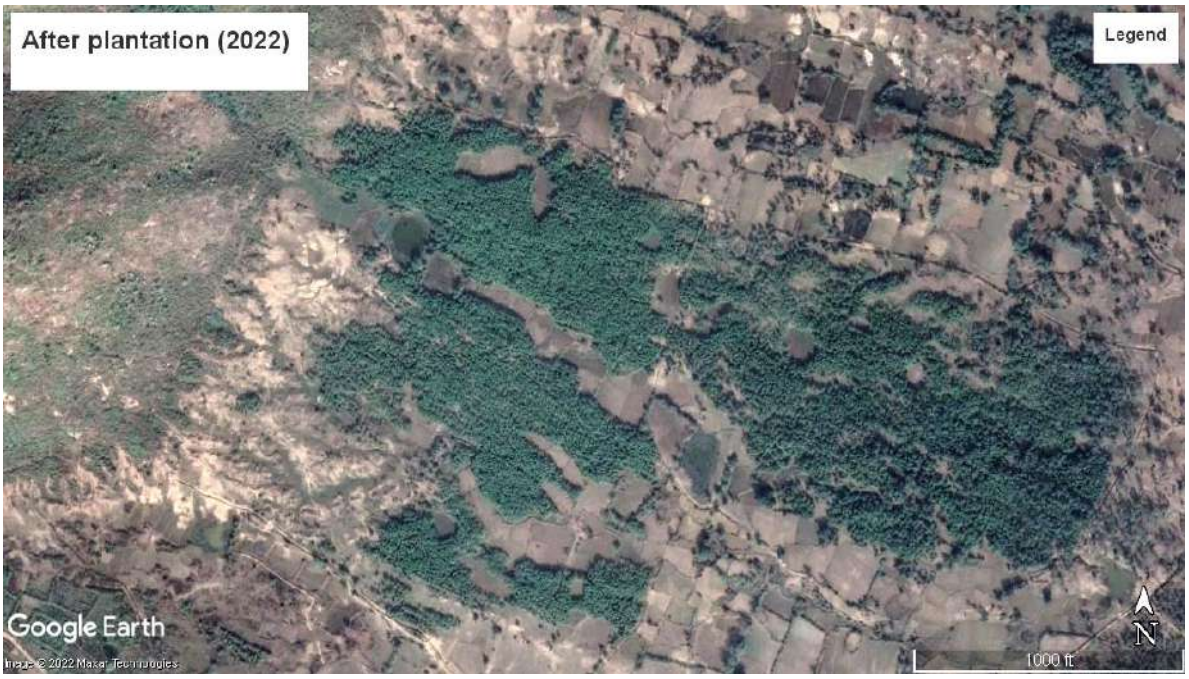

Figure 8.17: Google earth imagery showing establishment of large scale plantations of *Acacia auriculiformis* plantations in Purulia division (2016-22)

b) Site selection of the plantations sites in the natural landscape

Part of the plantation sites in the natural landscape were risky from the point of natural calamities. In Birbhum forest division, plantation was carried out adjacent to the banks of the river Ajay (Figure 8.18). As a result, some of the established plants were washed away during the monsoon flood and others were severely damaged. Also, the avenue plantation taken up along the road in Purulia district already passed through dense forest area (Figure 8.19).

Figure 8.18: Riverine plantations along the banks of river Ajay impacted by monsoon floods

Figure 8.19: Avenue plantations taken up along the road that passed through dense Sal forests in Purulia division

8.6 Suggestions

Overall the forestry plantations have come up well and the following suggestions are being provided to further strengthen the outputs and outcomes of the programme in future.

a) Planting monoculture of exotic species in natural plantations needs to be reconsidered

Akashmoni *(Acacia auriculiformis),* an exotic species has been included in the QGS NL/P/16 plantation model in the natural landscape (Figure 8.20). As discussed above, the introduction of this exotic species has detrimental effects on soil and other native species. It is suggested that native species that are suited to the locality and support local biodiversity be prioritized in the natural landscape. The QGS model implemented in other divisions such as Kangsabati (N) and Birbhum can be considered as they chose quick growing native species such as Arjun, Chitwan, Gamhar, Jamun, Sheesham, Siris, Minjiri, Chirol, Chakalta, Baheda etc. These species were suited to the environment and were performing well. The goal is to select tree species that are suited to the site, remain healthy, produce acceptable growth, and meet the objectives of the plantation. As the objective of the NMCG forestry plantations is to restore the river hydrology, native species that are multi-purpose should be prioritized over exotic ones. We suggest that the state forest department reconsider the use of exotics specially monoculture of *Acacia auriculiformis* in the natural landscape.

Figure 8.20: Monoculture of *Acacia auriculiformis* at Karma site of Purulia division

b) Careful selection of the plantation site needs to be done, supplemented with analysis of Google Earth images

In Birbhum forest division, the plantation was carried out adjacent to the bank of the river Ajay. As a result, a portion of the plantation was washed away during the monsoon floods. In Purulia forest division, an avenue plantation was taken up along a road that passed through dense Sal forests. We suggest that during site selection, Google Earth images of the last 10 years be studied using the 'historical imagery function' to assess the site suitability before taking up the plantation activity. Analysis of the Google Earth images needs to be integrated formally with plantation planning and site approval process.

c) Cattle proof trench (CPT) needs to be made more effective

The plantation in Karma site in Purulia division is adjacent to a village and lacks proper demarcation. To protect the plantations from livestock grazing, cattle proof trench (CPT) was constructed around the periphery of this site as the main protection measure (Figure 8.21). These CPTs are multipurpose, as they also store runoff during high rainfall events thereby improving soil moisture. But there is a provision of only 50m per ha in the plan. Based on the extent of biotic pressure, it is recommended to dig CPTs covering a larger section of the plantation periphery with regular maintenance to enhance their effectiveness. Hence, it is

suggested that this provision be enhanced to atleast 100 m per ha to ensure that all the vulnerable entry points are safeguarded with regular maintenance upto 3 years.

Figure 8.21: CPT is a multi-purpose structure as other than protection from livestock grazing it also helps in site demarcation and arresting surface runoff

d) Implementing economic trees plantation model in the agriculture landscape

The riverscape in West Bengal has undergone a major transformation by humans. The landuse adjacent to the Ganga river is smallholder farming and is human dominated. The non-availability of public lands in the Ganga riverscape is one of the biggest constraints in restoring the river Ganga. Hence, to have impact on scale, farmlands need to be taken up for tree planting by providing an economic incentive to the farmers. In the FRI DPR the AL/P/02 plantation model (Distribution of plants of fruit trees) has been made available for West Bengal. However, this model, has not been implemented yet. It is suggested that feasibility of this model in the agriculture landscape of West Bengal be assessed by the state forest department and implemented if found workable.

e) Iron tree guards are needed for the urban landscape plantations

The towns and cities in the urban landscape of West Bengal have very high population density. In such situations, iron tree guards are recommended as they protect the plants from the high biotic pressure. In the FRI DPR, the provision of iron tree guards has not been

provided to West Bengal state, especially when they are taking up large scale urban plantations in densely populated areas. Hence, it is recommended that the NL/P/06 (bamboo gabion linear mixed tree plantations) and NL/P/07 (iron gabion linear mixed tree plantations) be made available for the state of West Bengal so that these urban plantations can survive in the long run. Iron tree guards need to be used in roadside plantations in towns and cities, while bamboo tree guards can be used in the suburban and rural areas. Wherever iron tree guards are used, they must be reused once the plants establish after 4 to 5 years.

f) Ficus species can be included in the species mix

Ficus species such as Bargad, Peepal and other local fig species should be included in the plantation mix in large numbers specially in the natural landscape as these species have long life and provide valuable ecosystem services. These species have been tried out in the adjacent state of Bihar and is performing well.

g) Timely wage payment to the plantation chowkidars

The main strategy for protecting the plantations was by engaging chowkidars. However most of them did not receive their wages on time and often it got delayed by 6 -7 months. It is suggested that their wages be released on a timely basis. Also, it is recommended to enhance the number of chowkidars from one per 10 ha presently to one per 5 ha to ensure better plantation protection translating to higher survival and growth.

8.7 References

Bhattacharya, B. K. et. al., (1985). District Gazetteers Purulia. State Editor, West Bengal District Gazetteer, Calcutta.

Das S. (1986). Nursery and plantation technique of *Acacia auriculiformis*. silviculture Research Division, bulletin No. 7. Chittagong (BD): Bangladesh Forest Research Institute.

Haque, M. M., Ni, Y., Akon, A. J. U., Quaiyyum, M. A., & Jahan, M. S. (2021). A review on *Acacia auriculiformis*: importance as pulpwood planted in social forestry. *International Wood Products Journal*, 12(3), 194-205.

India State Forest Report (2021), Forest Survey of India, Ministry of Environment, Forest and Climate Change, Dehradun.

Indian Metrological Department, G. O. (2008). Climate of West Bengal.

Mahato, M. K., & Jana, N. C. (2021). Effects of Sonajhuri (*Acacia auriculiformis*) plantation on soil health in Purulia district, West Bengal, India. In *Forest Resources Resilience and Conflicts* (pp. 343-358). Elsevier.

Mallick, J. K. (2019). An updated checklist of the mammals of West Bengal. Journal on New Biological Report, 8(2), 37-123.

Mishra, S. (2012). Climate change adaptation in arid region of West Bengal. Climate Change Policy Paper III, WWF India. Bengal. Indian State Forest Report. Forest Survey of India. (2021)

State Forest Report (2019). Government of West Bengal.

West Bengal Forest Department, Government of West Bengal (2011). The Preparatory Survey on West Bengal: Integrated Forest Development and Biodiversity Conservation Project. Japan International Corporation Agency.

Chapter 9

Policy Analysis of the Programme Design

We collated the global best practices on ecorestoration and the experience gained in the first phase of this programme and using this lens analysed the policy design of the NMCG funded "Forestry Interventions for Ganga" programme.[30] We discuss the typology of restoration approaches and based on this analysis and the experience gained in the first phase, suggest improvements in the design of this programme to make it more effective in the next phase.

9.1 Selecting the suitable restoration approach

Approaches to restoration of degraded ecosystems depend primarily on the state of the residual vegetation which is a reliable indicator of the potential for natural regeneration. The degree of restoration elevates a degraded ecosystem to a higher level in the restoration staircase just like ecosystem services decline in a stepwise manner with increasing anthropogenic impacts (Figure 9.1).[31] In general, depending upon the degree of degradation, forest ecosystems are categorized into degraded, damaged and destroyed (Table 9.1). Degraded ecosystems are characterized by partial denudation of the original vegetation, with soils and seed banks intact. In such sites, a 'natural restoration' approach of ending the drivers of degradation, and protection, will enable the natural regeneration. Damaged ecosystems are intermediate levels of degradation where soils are intact but diverse sources of seed are lacking. Management of these ecosystems would be through 'assisted restoration' of native species with an objective to enhance the biodiversity. On the other hand, destroyed ecosystems are characterized by complete damage of the ecosystem structure and functioning (e.g., mined, overgrazed, burnt sites). Reclamation or 'reconstructive restoration' of these areas through vegetative means would be the only viable option in areas where effect of soil removal or toxic substrata limit the establishment and growth of native vegetation. In contrast to natural and assisted restoration, reconstructive restoration is generally practiced by planting of nursery-grown seedlings, direct seeding, and/or by manipulation of disturbance regimes (for example, thinning and burning) to speed up the recovery process, often at a high cost.[32]

[30] FRI DPR 2016
[31] Chazdon 2008
[32] Crouzeilles et al. 2017

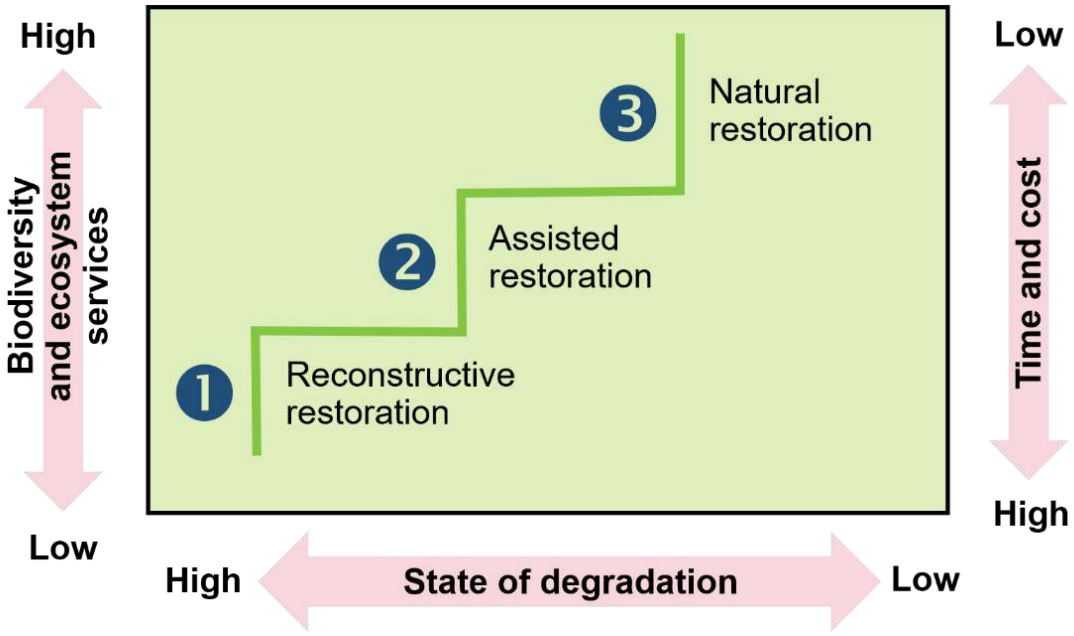

Figure 9.1: The Restoration Staircase. Depending on the state of degradation of an initially forested ecosystem (1–destroyed, 2–damaged, 3–degraded), a range of restoration approaches (1–reconstructive, 2–assisted, 3–natural) can restore levels of biodiversity and ecosystem services given adequate time, safety from further anthropogenic impacts and financial investment (Adapted from [33])

Determining the choice of restoration (natural, assisted or reconstructive) technique generally relies on the degree of damage, rate of ecosystem recovery, the landscape context, restoration goals, funds, time, costs etc.[34] Thus, restoration practitioners and stakeholders must look upon ecological restoration as a set of complementary approaches, viz., natural, assisted or reconstructive, based on their suitability to the local context. For example, restocking of native plants in sites with heavy disturbance or that are severely infested with invasive species, would require reconstructive approaches such as systematic replacement of invasive species by native species. Hence, restoration approaches need to be looked upon as a continuum where natural restoration might work best at sites with low degradation, reconstructive restoration for sites with high degradation and with assisted restoration suited for sites with intermediate levels of degradation.[35]

[33] Chazdon 2008
[34] Holl and Aide 2011
[35] Atkinson and Bonser 2020

Table 9.1: Mapping the extent of ecosystem degradation and the most suitable restoration approach

Degradation type	Restoration approach	Description
Degraded ecosystem with soils intact and diverse seed sources available	Natural restoration	Ending degradation, e.g. modifying anthropogenic pressure regimes such as grazing practices, reduction of logging, fire protection etc.
Damaged ecosystem where soils are intact, but diverse seed sources are lacking	Assisted restoration	A combination of the above strategy with biotic and abiotic interventions, for example: *Abiotic* Active remediation of substrate, habitat creation, reshaping watercourses, reintroduction of environmental water flows, promoting seed dispersal and germination, fostering of succession process etc. *Biotic* Invasive species management, reintroduction of local species, augmenting depleted populations of species, etc.
Destroyed ecosystem where soils have been removed or with toxic substrata	Artificial or Reconstructive restoration	A combination of the above strategies, along with reintroducing a major proportion of the desired biota, possibly mimicking natural successional dynamics.

(Source: Adapted from [36])

9.2 Review of tropical ecological restoration experiences

Tropical forests represent one of the most diverse habitats and across their range are under threat of degradation. Recovery of these ecosystems is the biggest challenge. These forests because of weather fluctuations, greater species diversity, shallow soils and intricate microhabitats are complex to restore. Large-scale plantations of few, fast growing and hardy species while may appear attractive in the short term, may not support a wide range of species in the future[37]. In many cases, natural and assisted restoration can help to achieve greater success than intensive interventions and are far less costly. [38] Also, intensive

[36] Atkinson and Bonser 2020
[37] Chazdon 2018
[38] Chazdon 2018

afforestation and forest expansion is a threat to grasslands and open canopy woodlands.[39] Furthermore, a meta-analysis of 133 studies revealed that natural restoration surpasses active restoration in achieving tropical forest restoration success for all three biodiversity groups (plants, birds, and invertebrates) and five measures of vegetation structure i.e. cover, density, litter, biomass, and height.[40] These studies also reveal that natural and assisted restoration would be cost-effective and appropriate option, and in some cases, reconstructive restoration can even cause more harm than good. For instance, use of heavy earth-moving machinery during planting can disturb the soil and damage naturally re-sprouting vegetation.[41]

The major barrier in implementing global restoration is fund shortage and hence reducing restoration costs is essential to upscale restoration. For example, a meta-analysis of 240 restoration studies suggests that for ecosystems with moderate levels of degradation, natural and assisted restoration can be more cost-effective because most of these systems recovered naturally from disturbances in about 10 years.[42] A global study analyzing 2,200 forest plots across the American and West African tropics revealed that while natural regeneration is frequently disregarded in favour of tree plantations, in tropical forests with low to medium levels of degradation, natural restoration yields better results than artificial restoration.[43] For this study, more than 90 researchers from all over the world came together and their takeaway message was not to plant trees and nature is doing an excellent job by itself. These forests have regrown after eliminating disturbance such as fire, grazing, clearance, etc. Global restoration experience in the tropics and subtropics unequivocally points to the conclusion that natural and assisted restoration yield better results than reconstructive restoration in ecosystems that have low to medium levels of degradation. Depending on local site conditions and people's needs, the policy and practice of ecological restoration should rely on natural and assisted regrowth wherever possible, and use active reconstructive restoration planting only where it is necessary[44]. A global synthesis study was undertaken to provide evidence on whether plantation forestry restores biodiversity or creates green deserts.[45] Results suggest that plantations would contribute to biodiversity when established on degraded lands rather than replacing natural ecosystems, such as forests, grasslands, and shrublands, and when indigenous tree species are preferred over exotic ones.

[39] Veldman et al. 2015
[40] Crouzeilles et al. 2021
[41] Holl and Aide 2011
[42] Jones and Schmitz, 2009
[43] Poorter et al. 2021
[44] Poorter et al. 2021
[45] Bremer and Farley 2010

9.3 Analysis of the design of the "Forestry interventions for Ganga"

'What to plant', 'where to plant' and 'how much to plant', are key decisions that need to be carefully evaluated based on ecological principles and needs of local communities rather than on survival percentage or growth potential. Planning a restoration project must consider the key performance indicators to focus not only on survival and growth but also on the suitability of site for tree planting, species selection and active community involvement. Selecting deforested planting sites, adapting the plantation design by accounting for the threats, locality factors and preferring native species can significantly enhance ecosystem restoration and biodiversity conservation. Based on this global literature review and field experience gained from implementing the "Forestry Interventions for Ganga" programme over the last five years, we discuss the aspects of the programme design that need to be strengthened and provide suggestions that we hope will be adopted in the next phase of this initiative.

9.3.1 Addressing the drivers of degradation before planting

In sites where the rate of biomass removal (grazing, harvesting, firewood collection etc.) is faster than primary production, it is imperative to address the livelihood needs of the local community before afforestation (or restoration) is attempted. Afforestation projects implemented in isolation without addressing the causes and drivers of deforestation in consultation with the local community will remain a 'band aid' approach to degradation (Figure 9.2) and not provide a lasting cure.[46]

Figure 9.2: Only the mounds (where trees were planted) remain as village grazing lands were taken up for afforestation in Bihar

[46] Blignaut 2009

The drivers of degradation such as over-grazing, tree felling, forest fires, tragedy of the commons, infestation by invasive species, weak enforcement, etc. in the proposed restoration sites need to be identified and plantations should commence only when these have been effectively addressed. The most apt way would be to take local communities into confidence and make them equal partners in the revival process as they are fully aware about the causes of degradation and the remedial measures thereof. The consent and participation of the Gram Sabha(s) who customarily use these forests in restoration projects is a must. They particularly need to be involved and consulted in site identification, species selection execution and protection leading to restoration, so that they develop a sense of ownership.

We suggest that for the natural landscape, the prescribed plantation models need to factor in the ground situation. The main causes of plantation failure are grazing, drought, frost, fire, floods, landslides etc. These threats existed even before the plantations were planned, and addressing these threats using mitigation and adaptation measures should be made a precondition before planting is taken up. In sites, where this is not possible, plantations should not be taken up as they will meet the same fate as the original forests that got degraded. The second option is to adopt a mitigation strategy wherein the design of the plantation model adequately takes into account these threats and risks such as mound plantations in water logged areas, selecting species that can withstand water logging, effective fencing in grazed areas, community partnership and ownership, provision of watering during summers etc. Freedom and flexibility needs to be provided to the state forest departments to include these components in the existing plantation models based on site specific threat perception and locality factors.

9.3.2 Permitting site specific plantation models

The summary of all the plantation models prescribed in the FRI DPR is provided for in Annexure 10.3. Analyzing these plantation models shows that only artificial or reconstructive restoration is envisaged in all the states except West Bengal. Most of the plantation models in the states of Uttarakhand, Uttar Pradesh, Bihar and Jharkhand are reconstructive in nature with an intensive 800 or more trees and shrubs prescribed per hectare. As plantation models are not available for moderately degraded and damaged ecosystems, the broad brush, expensive reconstructive afforestation model is applied irrespective of the site condition. Only West Bengal has a mix of reconstructive, assisted and natural restoration models available. For degraded forests under model NL/P/14 - natural restoration is prescribed by encouraging Sal coppice, soil working and fencing. Similarly, in NL/P/15 - quality shoots of Sal on a stump are selected and the remaining coppice shoots removed to improve tree form and wood quality. Riverbank restoration is envisaged under NL/P/16, where the grasses, herbs and shrubs are promoted. This is in contrast to the NL/P/01 model in Khadar area of

Uttar Pradesh which envisaged planting of 625 trees/shrubs in the riverine grasslands. Also under NL/P/18 in West Bengal, the eradication of invasive species and restoration by planting of mangrove species is prescribed. West Bengal has made available the whole range of natural, assisted and reconstructive restoration models to suit different site conditions along the gradient of degradation i.e. degraded, damaged and destroyed. While in the other states, only the reconstructive model is prescribed even in natural grasslands and in moderately degraded and damaged forest ecosystems.

As discussed earlier, several studies on tropical forests clearly show that success of ecological restoration is higher for natural and assisted regeneration compared to reconstructive restoration in moderately degraded habitats. This result runs counter to the prevailing policy and practice that active restoration should be the preferred approach for accelerating the recovery of biodiversity. Restoration science and practice suggests that a more site-specific and diverse restoration strategy with three models of restoration, i.e., natural, assisted and reconstructive based on the degree of degradation would be far more successful. Research studies that have analyzed tropical forest restoration initiatives challenge the widely held notion that natural forest regeneration has limited conservation value and that active reconstructive restoration should be the default ecological restoration strategy.[47] These studies point out that not only are natural and assisted restoration strategies more successful but are cost effective as well in moderately degraded habitats.

Hence, we suggest that the entire gamut of ecological restoration strategies (natural, assisted and reconstructive) need to be made permissible in the second phase of the "Forestry interventions of the Ganga". Local site specific models that take into consideration the local site conditions and people's needs and are recommended by the state forest departments need to be made permissible, instead of relying on the present approach of a centralized, reconstructive model. What this would for instance imply is that if there is space for only 150 trees per hectare in moderately degraded and 200 trees per hectare in damaged sites, then the same should be permitted. We suggest that the states be provided the freedom and flexibility to adapt the existing natural landscape plantation models to the local context so that the field realities are reflected in it. This approach can result in significant cost savings as only need based investments will be made.

9.3.3 Avoiding exotics and planting only indigenous species

Species selection in afforestation projects is often biased towards fast-growing, non-native tree species that thrive in disturbed habitats but have limited scope for fostering biodiversity

[47] Crouzeilles et al. 2017

or other species that would benefit local forest-dependent communities. The FRI DPR in the general principles applicable to all models in all landscapes also prescribes that, "*Native species of trees, shrubs and herbs will be planted and mixture will be used as far as possible in preference of pure plantation*." While largely native species have been planted, there have been deviations as well in few locations. Invasive alien species (IAS) such as *Prosopis juliflora* (vilayati babul) planted in Ganga Khadar areas of Uttar Pradesh would cause irreversible damage to the riverscape. Also species that are not native to the ecosystem (exotics) such as *Acacia auriculiformis* in West Bengal and others should not be planted in the natural landscape. Such inappropriate plantations are more accurately described as 'green deserts'.

Hence, we suggest that an advisory should be provided to mandatorily select suitable native species for planting, avoiding exotic species, preventing monocultures and not prioritizing commercial species in natural landscapes.

9.3.4 Protecting open natural ecosystems from afforestation

Deep misunderstanding exists about grassy biomes, as well as their denigration and devaluation relative to forests.[48] Open natural ecosystems such as grasslands, savannah, meadows, wetlands, etc. must be excluded from tree plantations as it would lead to change in their fundamental character (Figure 9.3). Grassland ecosystems such as Khadar along the Ganga and its tributaries should be safeguarded from forest expansion drives. Solely relying on remote sensing and GIS studies for identifying potential plantation sites without adequate ground truthing can be misleading. It is suggested that forest expansion should be strictly avoided in sites where historically they did not harbour forests and instead reforestation should be carried out by planting trees on deforested lands.

9.3.5 Mandatory planting of grasses and sedges needs to be discontinued

Many of the NL plantation models such as NL/H/03, NL/H/04, NL/H/05, NL/H/06, NL/H/07, NL/H/08, NL/H/09, NL/P/01, NL/P/02, NL/P/03 have made provision of 200 to 400 grasses and sedges to be planted per ha. In the natural landscape, even in degraded sites, grasses and sedges being pioneer species, regenerate profusely on their own and do not need to be artificially planted (Figure 9.4). They are naturally dispersed by wind and water and colonize the landscape spontaneously. In this context, it appears frivolous to plant grasses and sedges in deforested sites. The only context where this approach can be suitable is the restoration of a grassland such as meadows, savannah, flood plains (khadar) etc. During monitoring and evaluation, it is impossible to figure out whether these grasses/sedges were planted or have

[48] Veldman *et al.* 2015

Figure 9.3: Alluvial grasslands of the Ganga Khadar afforested with *Prosopis juliflora*—an invasive alien species under an ecologically inappropriate forest expansion drive

Figure 9.4: Natural regeneration of shrubs and grasses is profuse in the riverscape. Spot the shrubs/grasses that were planted and the ones that have naturally regenerated

regenerated naturally. Also grass species often form mats and are hence not amenable to numerical counting.

Hence, we suggest that the mandatory planting of grasses and sedges be discontinued. These shall be included only when explicitly recommended by the state forest departments under specific contexts while providing reasons for their inclusion.

9.3.6 Mandatory medicinal plants component to be discontinued

Many plantation models included medicinal plants in the species mix. In NL/H/01 – alpine meadows conservation it appears reasonable as there are several medicinal plants that occur naturally in the alpine areas that can be prioritized in planting. The plantation models of NL/H/02, NL/H/03, NL/H/04, NL/H/05, NL/H/06, NL/H/07, NL/H/08, NL/H/09, NL/P/01 and NL/P/03 have a provision of 200 medicinal plants to be planted per ha. Due to this, in many natural landscape sites the field personnel planted medicinal plants that were not suited to that habitat and consequently did not perform well. On the ground also, these medicinal plants plantations of give Amla, Arjun, Jamun etc. are not adding any value. The objective of the "Forestry Interventions of Ganga" is to provide a nature based solution to augment nirmal and aviral Ganga. The strategy for doing this is by restoring forests in the natural landscape and enhancing tree cover in urban and agricultural landscapes. Planting of medicinal plants mandatory in the plantation models conflicts with the principles of ecological restoration as the species selected may not be native to these ecosystems or the planting material may not be readily available. Also, plants provide an array of provisioning, regulating and supporting ecosystem services such as providing food, firewood, fodder, regulating climate, carbon sequestration, biodiversity conservation, groundwater recharge etc. This added emphasis on medicinal plants would have been justified if the programme objective is to create medicinal plant conservation areas or develop an insitu germplasm of endangered medicinal plants. It seems ecologically frivolous to plant medicinal plants, when the focus is on restoring entire ecosystems. Hence, we suggest that the mandatory planting of medicinal plants be discontinued and removed from these planting models (except NL/H/01). These should be included only when explicitly recommended by the state forest departments under specific contexts while providing reasons for their inclusion.

9.3.7 Economic tree plantations in the agriculture landscape to be scaled up

In the states of Uttar Pradesh, Bihar, Jharkhand and West Bengal, the landuse adjacent to the Ganga river and its tributaries is smallholder farming and is human dominated. There is a need to promote economic tree plantations in this agriculture landscape by implementing the plantations models AL/P/01 and AL/P/02 on large scale. Even in Uttarakhand the AL/H/01 model is showing good results and needs to be scaled up. Larger investments are needed to

scale up these plantations in the agricultural landscape as they are beneficial for nature and people both.

9.3.8 Scaling up soil and moisture conservation works in the plantations

In the plantations taken up in the natural landscape, works such as creation of water bodies and soil and water conservation structures should be dove tailed for improving soil moisture conditions. In Uttarakhand and West Bengal state, these works are showing good results.

9.3.9 Strengthening digital record keeping and spatial database of the plantations

For all plantations taken up, photographic documentation of the input, process, output and outcomes should be regularly done and made readily available in the division office. Also, the geo-referenced plantation polygon of the perimeter of the plantation as a KML file (as is done in CAMPA funded plantations) should be diligently recorded and stored with the division office for future reference. A special GIS database may also be established in NMCG to keep a record of these investments in natural capital. These steps will enable effective monitoring and evaluation in future as well.

9.4 References

Agarwal, S. (2009). Angiosperm species diversity and ecological assessment of Hastinapur Wildlife Sanctuary, India (Doctoral dissertation, PhD Thesis. Department of Botany, Aligarh Muslim University, Aligarh, India, 357pp).

Albert, C., Hack, J., Schmidt, S., & Schröter, B. (2021). Planning and governing nature-based solutions in river landscapes: Concepts, cases, and insights. *Ambio*, 50(8), 1405-1413.

Atkinson, J., & Bonser, S. P. (2020). "Active" and "passive" ecological restoration strategies in meta-analysis. *Restoration Ecology*, 28(5), 1032-1035.

Blignaut, J. N. (2009). Fixing both the symptoms and the causes of degradation: the need for an integrated approach to economic development and restoration. *J. Arid Environ*. 73 696-698.

Borah, B., Bhattacharjee, A., and Ishwar, N.M. (2018). Bonn Challenge and India: Progress on restoration efforts across states and landscapes. New Delhi, India: IUCN and MoEFCC, Government of India, New Delhi.

Clewell, A., Aronson, J., & Winterhalder, K. (2004). The SER international primer on ecological restoration.

Chazdon, R. L. (2008). Beyond deforestation: restoring forests and ecosystem services on degraded lands. *Science*, 320(5882), 1458-1460.

Coleman, E. A., Schultz, B., Ramprasad, V., Fischer, H., Rana, P., Filippi, A. M., ... & Fleischman, F. (2021). Limited effects of tree planting on forest canopy cover and rural livelihoods in Northern India. *Nature Sustainability*, 1-8.

Crouzeilles, R., Ferreira, M. S., Chazdon, R. L., Lindenmayer, D. B., Sansevero, J. B., Monteiro, L., ... & Strassburg, B. B. (2017). Ecological restoration success is higher for natural regeneration than for active restoration in tropical forests. *Science advances*, 3(11), e1701345.

FRI DPR (2016). Forestry interventions for Ganga, Detailed Project Report, Volume I and II, Forest Research Institute, Dehradun, India.

Gertler, P. J., Martinez, S., Premand, P., Rawlings, L. B., & Vermeersch, C. M. (2011). Impact evaluation in practice. World Bank Publications.

https://www.worldbank.org/en/programs/sief-trust-fund/publication/impact-evaluation-in-practice

Holl, K. D., & Aide, T. M. (2011). When and where to actively restore ecosystems? *Forest ecology and management*, 261(10), 1558-1563.

IFAD Evaluation Manual (2009). Methodology and Processes, IFAD, 2009.

http://www.ifad.org/evaluation/process_methodology/doc/manual.pdf

IIFM (2016). National Evaluation Manual for CAMPA Plantations, IIFM, 2016.

IPBES (2018). The IPBES assessment report on land degradation and restoration. Montanarella, L., R. Sholes, and A. Brainich (Eds.). Secretariat of the Intergovernmental Science – Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany. pp. 744.

Jones, H. P., & Schmitz, O. J. (2009). Rapid recovery of damaged ecosystems. *PloS one*, 4(5), e5653.

Lal, S. (1998). Rehabilitation of Ganga Khadar and Khola areas of western zone of UP by utilizing tall planting technique. *Indian forester*, 124(2), 99-115.

McLain, R., Lawry, S., Guariguata, M. R., & Reed, J. (2021). Toward a tenure-responsive approach to forest landscape restoration: A proposed tenure diagnostic for assessing restoration opportunities. *Land Use Policy*, 104, 103748.

NMCG AR (2020-21). Annual Report 2020-2021. National Mission for Clean Ganga (Registered Society under Societies Registration Act, 1860) Department of Water Resources, River Development & Ganga Rejuvenation Ministry of Jal Shakti, Government of India.

https://nmcg.nic.in/writereaddata/fileupload/19_NMCG%20Annual%20Report%202020-21English.pdf

UNDP (2009). Handbook on Planning, Monitoring and Evaluating for Development Results. United Nations Development Programme. 2009.

http://web.undp.org/evaluation/handbook/documents/english/pme-handbook.pdf

Veldman, J. W., Overbeck, G. E., Negreiros, D., Mahy, G., Le Stradic, S., Fernandes, G. W., ... & Bond, W. J. (2015). Where tree planting and forest expansion are bad for biodiversity and ecosystem services. *BioScience*, 65(10), 1011-1018.

Chapter 10

Annexures

10.1 List of project sites sampled

S. No	State	Year	Division	Model No.	Project Name	GPS reading	No. of Plants	Cost in Lakhs
1	Uttarakhand	2018-19	Lansdowne Soil Conservation	NL/H/08	Satpuli malli	29°54'36.44"N 78°42'39.54"E	10000	7.76
2	Uttarakhand	2018-19	Lansdowne Soil Conservation	NL/H/08	Bhayali	29°52'57.87"N 78°46'15.24"E	10000	7.76
3	Uttarakhand	2018-19	Lansdowne Soil Conservation	NL/H/08	Bhali	29°55'50.36"N 78°41'28.89"E	10000	7.76
4	Uttarakhand	2018-19	Lansdowne Soil Conservation	NL/H/08	Uneri 2	29°49'16.10"N 78°50'50.24"E	10000	7.76
5	Uttarakhand	2018-19	Lansdowne Soil Conservation	NL/H/08	Bhali 2	29°55'50.29"N 78°41'24.22"E	10000	7.76
6	Uttarakhand	2018-19	Lansdowne Soil Conservation	NL/H/08	Chaukadi	29°49'41.21"N 78°52'53.71"E	10000	7.76
7	Uttarakhand	2017-18	Alaknanda	NL/H/11	Tangari/Patal Ganga	30°28'40.90"N 79°27'39.20"E	107000	102.36
8	Uttarakhand	2017-18	Uttarkashi	NL/H/07	Nald-1	30°46'17.24"N 78°27'11.48"E	10000	8.72
9	Uttarakhand	2017-18	Uttarkashi	NL/H/07	Kawa 3B	30°45'30.93"N 78°23'31.57"E	10000	8.72
10	Uttarakhand	2018-19	Uttarkashi	NL/H/07	Utrao 5A	30°46'1.61"N 78°26'53.10"E	10000	8.37
11	Uttarakhand	2017-18	Uttarkashi	NL/H/07	Sauragarh 3A	30°45'16.85"N 78°34'41.52"E	10000	8.72
12	Uttarakhand	2017-18	Uttarkashi	NL/H/07	Dilasaud 1	30°44'13.20"N 78°21'57.86"E	10000	8.72
13	Uttarakhand	2018-19	Uttarkashi	NL/H/07	Nirakot 2	30°44'34.7"N 78°27'82.2"E	10000	8.37
14	Uttarakhand	2018-19	Uttarkashi	NL/H/03	Hurri 6A	30°54'55.42''N 78°40'50.74"E	10000	8.37
15	Uttarakhand	2018-19	Uttarkashi	NL/H/03	Tihar 6 B	30°52'59.16"N 78°37'59.68"E	10000	8.37
16	Uttarakhand	2017-18	Uttarkashi	NL/H/03	Raithal 5A	30°50'22.55"N 78°35'35.18"E	10000	8.72
17	Uttarakhand	2018-19	Uttarkashi	NL/H/03	Sukhi 1A	31° 0'38.74"N 78°42'42.16"E	10000	8.37
18	Uttarakhand	2017-18	Uttarkashi	NL/H/07	Dharasu 3	30°37'14.10"N 78°19'6.87"E	10000	8.72
19	Uttarakhand	2017-18	Uttarkashi	NL/H/07	Badethikhand 2	30˚36.568' N 78˚18.534' E	10000	8.72
20	Uttarakhand	2018-19	Uttarkashi	NL/H/07	Kandaak 2 (1)	30° 36.528' N 78° 16.164' E	10000	8.37
21	Uttarakhand	2017-18	Uttarkashi	NL/H/07	Dhanari 1, plot 1	30°39' 48.6''N 78° 22' 4.7"E	10000	8.72
22	Uttarakhand	2018-19	Uttarkashi	NL/H/07	Gamri 2	30°37'14.73"N 78°19'8.06"E	10000	8.37
23	Uttarakhand	2017-18	Uttarkashi Soil Conservation	NL/H/06	Dikholi soyam 2	30˚37'56.5"N 78˚30'21.3"E	10000	8.43
24	Uttarakhand	2017-18	Uttarkashi Soil Conservation	NL/H/06	Chamkot	30°44'1.80''N 78°22'53.62"E	10000	8.43
25	Uttarakhand	2017-18	Tehri dam 2	NL/H/06	Kathogi soyam	30˚36.818'N 78˚15.693'E	10000	8.43

S. No	State	Year	Division	Model No.	Project Name	GPS reading	No. of Plants	Cost in Lakhs
26	Uttarakhand	2017-18	Tehri dam 2	NL/H/06	Hatnali soyam	30° 40.164' N 78° 11.680' E	10000	8.43
27	Uttarakhand	2018-19	Rudraprayag	NL/H/07	Rudraprayag reserve 10A	30°17'24.3''N 79°01'31.3''E	10000	9.84
28	Uttarakhand	2017-18	Rudraprayag	NL/H/07	Ratanpur 11	30°20'5.5''N 78°57'53.4''E	10000	8.80
29	Uttarakhand	2018-19	Rudraprayag	NL/H/07	Jakhal 10	30° 20.535' N 78° 57.896' E	10000	9.84
30	Uttarakhand	2018-19	Rudraprayag	NL/H/07	Tolab van panchayat	30°21'15.4''N 78°59'22.5''E	10000	9.84
31	Uttarakhand	2017-18	Haridwar	NL/H/08 /09	Sambalgarh 5 (30ha)	29°45'41.3''N 78°15'17.6''E	30000	23.30
32	Uttarakhand	2017-18	Haridwar	NL/H/08 /09	Sambalgarh 5 (20ha)	29°45'55.7''N 78°15'28.1''E	20000	15.53
33	Uttarakhand	2017-18	Haridwar	NL/H/08 /09	Pili 2 B	29°52'12.5''N 78°15'17.8''E	15000	11.65
34	Uttarakhand	2017-18	Haridwar	NL/H/08 /09	Anjani 1&2	29° 54.606' N 78° 10.178' E	25000	19.42
35	Uttarakhand	2017-18	Dehradun	NL/H/08	Fatehpur block	30˚11.243' N 78˚08.106' E	15000	11.90
36	Uttarakhand	2018-19	Dehradun	NL/H/08	Vanvah 1	30˚07.921' N 78˚07.139' E	10000	7.93
37	Uttarakhand	2018-19	Dehradun	NL/H/08	Chandi 1	30° 05.283'N 78° 10.736' E	15000	11.89
38	Uttarakhand	2017-18	Dehradun	NL/H/08	Chandi 2	30˚06.212' N 78˚10.031' E	10000	7.93
39	Uttarakhand	2018-19	Dehradun	NL/H/08	Bibiwala 7B	30° 05.640' N 78° 14.565' E	10000	7.93
40	Uttarakhand	2018-19	Dehradun	NL/H/08	Lalpani 2 (15ha)	30° 05.300' N 78° 15.532 E	15000	11.89
41	Uttarakhand	2017-18	Dehradun	NL/H/08	Lalpani 2 (10ha)	30° 05.833' N 78° 15.946' E	10000	7.93
42	Uttarakhand	2018-19	Mussourie	NL/H/08	Bandal 1 part 1	30˚21.923' N 78˚06.893' E	10000	7.71
43	Uttarakhand	2018-19	Mussourie	NL/H/08	Bandal 1 part 2	30˚22.329' N 78˚06.956' E	10000	7.71
44	Uttarakhand	2018-19	Mussourie	NL/H/08	Chamasari 1	30°23'5.54"N 78°7'10.22"E	20000	15.43
45	Uttarakhand	2018-19	Mussourie	NL/H/08	Sripur 2 B	30° 20.788' N 78° 09.882' E	20000	15.43
46	Uttarakhand	2018-19	Mussourie	NL/H/08	Dwara 6 (10ha)	30° 19.926' N 78° 07.895' E	10000	7.71
47	Uttarakhand	2018-19	Mussourie	NL/H/08	Dwara 6 (20ha)	30° 20.589' N 78° 07.927' E	20000	15.43
48	Uttarakhand	2016-17	Uttarkashi	UL/A/01	Lambgaon Motor Marg	30°43'33.1"N 78°26'44.9"E	2700	9.58
49	Uttarakhand	2016-17	Dehradun	UL/A/02	Rishikesh-Haridwar NH (4-11KM)	30°04' 27.4'' N 78°15'16.5''E	1100	12.00
50	Uttarakhand	2016-17	Dehradun	UL/A/03	Rishikesh- Haridwar NH (Van Nigam Depot)	30°05.919' N 78°16.505' E		
51	Uttarakhand	2017-18	Alaknanda	AL/H/01	Diyarkot	30˚13'47.0"N 79˚13' 44.2"E	200	0.01
52	Uttarakhand	2017-18	Alaknanda	AL/H/01	Jakh	30˚14'14.1"N 79˚13'32.7"E	120	0.01
53	Uttarakhand	2017-18	Nandadevi	AL/H/01	Debgram	30° 32' 19.8"N 79° 27' 29.0" E	120	0.01
54	Uttarakhand	2017-18	Nandadevi	AL/H/01	Tapovan	30˚29'25.6"N 79˚37'36.1"E	135	0.01
55	Uttarakhand	2018-19	Uttarkashi	AL/H/01	Dharali	30°02'23.7''N 78°46'33.2''E	200	0.02
56	Uttarakhand	2018-19	Uttarkashi	AL/H/01	Sukki	30°00'37.9''N 78°42'47.1''E	100	0.01

S. No	State	Year	Division	Model No.	Project Name	GPS reading	No. of Plants	Cost in Lakhs
57	Uttar Pradesh	2016-17	Prayagraj	UL/I/01	Allahabad University different Hostel, campus & nearby places	25°27'49.10"N 81°51'38.72"E	825	18.60
58	Uttar Pradesh	2016-17	Prayagraj	UL/A/01	Govindpur Colony Marg	25°29'27.68"N 81°52'34.51"E	500	11.30
59	Uttar Pradesh	2016-17	Prayagraj	UL/A/01	New Cantonment area different roads & near by places	25°27'4.31"N 81°48'22.81"E	596	13.42
60	Uttar Pradesh	2016-17	Prayagraj	UL/A/01	T.P. Nagar Mundra , Ganga Vihar colony, Nayay nagar colony, Jhalwa	25°26'45.37"N 81°47'0.67"E	410	9.24
61	Uttar Pradesh	2016-17	Varanasi	UL/A/01	Ramnagar to Panchwati Marg	25°15' 59.0''N 83° 2' 35.8'' E	100	3.09
62	Uttar Pradesh	2016-17	Varanasi	UL/A/01	Padav To Ramnagar Marg	25°16'27.94"N 83° 1'51.05"E	150	4.63
63	Uttar Pradesh	2016-17	Varanasi	UL/A/01	Balaji Nagar Samneghat	25°16'28.25"N 83° 0'33.66"E	128	3.94
64	Uttar Pradesh	2016-17	Varanasi	UL/A/01	Brijenclave Colony Sundarpur	25°17'1.87"N 82°58'55.58"E	282	8.74
65	Uttar Pradesh	2016-17	Varanasi	UL/A/01	Gautam Nagar Colony Chitaipur	25°15'16.49"N 82°58'2.92"E	102	3.17
66	Uttar Pradesh	2016-17	Varanasi	UL/A/01	Shreeram Nagar colony	25°17'38.11"N 82°58'29.98"E	100	3.09
67	Uttar Pradesh	2016-17	Varanasi	UL/A/01	Sivajee Nagar Colony	25°18'24.84"N 82°58'47.47"E	100	3.09
68	Uttar Pradesh	2016-17	Varanasi	UL/A/01	Nirala Nagar Colony	25°18'33.04"N 82°58'42.44"E	250	7.71
69	Uttar Pradesh	2018-19	Hardoi	NL/P/01	Bawatmau Van Block	27°0'50.29"N 80° 0'8.22"E	33000	30.59
70	Uttar Pradesh	2018-19	Hardoi	NL/P/01	Katri Arwal Van Block	27°12'20.50"N 79°46'45.40"E	20625	19.12
71	Uttar Pradesh	2016-17	Prayagraj	NL/P/01	Jaswa Gram Samaj	25°19'16.36"N 82°15'7.05"E	12500	124.83
72	Uttar Pradesh	2016-17	Prayagraj	UL/A/01	Tagore Town, Allapur area, Bairahna area, Medical college & near by areas	25°27'10.43"N 81°51'49.63"E	330	7.43
73	Uttar Pradesh	2016-17	Prayagraj	UL/A/01	Teliyarganj + Mehdauri Colony	25°29'50.67"N 81°51'32.59"E	300	6.74
74	Uttar Pradesh	2018-19	Hardoi	NL/P/01	Katri Chochpur Van Block	27°10'52.59"N 79°48'45.60"E	24750	22.94
75	Uttar Pradesh	2018-19	Hardoi	NL/P/01	Gadanpur Van Block	27°15'37.01"N 79°41'51.05"E	20625	19.12
76	Uttar Pradesh	2018-19	Badaun	NL/P/01	Ulaikhera	27°51'28.31"N 78°56'56.42"E	49500	48.60
77	Bihar	2016-17	Patna	NL/P/07	Gangapul Phunch Path, Digha	25˚38'51.84'N 85˚04'49.99"E	1000	41.06
78	Bihar	2017-18	Patna	NL/P/07	Gangapul Pahunch Path	25˚39'03.42'N 85˚04'57.74''E	500	19.54
79	Bihar	2017-18	Patna	NL/P/07	Barh Thana Nagar Parisad to Alakhanath Ghat	25°28'15.57''N 85° 4'57.64''E	300	11.73
80	Bihar	2016-17	Begusarai	NL/P/06	Godargama To Vrindavan	25°24'13.04''N 86°09'48.21''E	1800	39.96
81	Bihar	2016-17	Begusarai	NL/P/06	Panchvir To Bahloria	25°24'03.88''N 86°24'19.95''E	1200	26.63
82	Bihar	2017-18	Begusarai	NL/P/07	Sakti Chaura to Lakhminia Bazar	25°25'21.40''N 86°17'41.93''E	400	15.63
83	Bihar	2017-18	Bhagalpur	NL/P/06	Ultapul to Jagdishpur	25°13'6.52"N 86°58'23.28"E	12000	249.20
84	Bihar	2017-18	Bhagalpur	NL/P/06	Nathnagar to Shahkund	25°12'15.63"N 86°55'0.54"E	9000	186.90
85	Bihar	2016-17	Bhagalpur	NL/P/07	Raghopur To Koji Koraiya Ganga Bandh	25°20'11.08"N 86°58'8.92"E	6000	133.19
86	Bihar	2016-17	Bhagalpur	NL/P/10	Kastikari To Chandan Nadi Bandh(Badua Nadi Bandh)	25°7'45.60"N 86°43'32.77"E	6000	32.79

S. No	State	Year	Division	Model No.	Project Name	GPS reading	No. of Plants	Cost in Lakhs
87	Jharkhand	2017-18	Sahibganj	NL/P/11	Linear Plantation (Multi Row with barbed wire fencing)	25°11'6.25"N 87°45'26.16"E	87000	66.82
88	Jharkhand	2017-18	Sahibganj	NL/P/06	Bamboo Gabion Plantation (B.G.) (Linear Plantation Road/Rail Side)	24°56'2.85"N 87°46'31.15"E	7000	94.48
89	Jharkhand	2018-19	Sahibganj	NL/P/06	Bamboo Gabion Plantation (B.G.) (Linear Plantation Road/Rail Side)	25°15'37.96"N 87°32'15.82"E	5000	74.52
90	West Bengal	2017-18	Kangsabati (N)	NL/P/13	QGS	23°13'37.41"N 86°41'7.31"E	49600	15.15
91	West Bengal	2018-19	Purulia	NL/P/16	QGS	23°10'4.76"N 86°11'57.72"E	77040	30.20
92	West Bengal	2018-19	Purulia	UL/A/01	Avenue Plantation	23°13'28.04"N 86° 6'57.04"E	8200	43.45
93	West Bengal	2018-19	Birbhum	NL/P/13	QGS	23°45'10.54"N 87°10'16.03"E	56000	25.42
94	West Bengal	2017-18	URF	UL/I/01	Institutional Plantation	22°58'42.63"N 88°25'41.85"E	54672	61.21
95	West Bengal	2018-19	URF	UL/A/01	Avenue Plantation	22°37'8.34"N 88°22'45.46"E	17800	65.25
						Total	**1,232,360**	**2,180.19**

10.2 List of species planted

S. No.	Vernacular name	Botanical name
1	Aakando	*Calotropis gigantea* (L.) WT Aiton
2	Aam	*Mangifera indica* Linn.
3	Acacia, Akashmani, Sonajhuri	*Acacia auriculiformis* Benth.
4	Akhrot	*Juglans regia* Linn.
5	Amaltas, Sonalu	*Cassia fistula* Linn.
6	Amla, Aawla, Aamlaki	*Emblica officinalis* Gaertn.
7	Amrud	*Psidium guava* L.
8	Anar	*Punica granatum* L.
9	Anga	*Fraxinus americana* L.
10	Archa	*Rheum webbianum* Royle.
11	Areca palm	*Dypsis lutescens* (H.Wendl.) Beentje & J.Dransf.
12	Arjun	*Terminalia arjuna* Roxb.
13	Asan	*Terminalia elliptica* Willd.
14	Ashoka, Debdaru	*Polyalthia longifolia* (Sonn.) Thwaites var. pendula
15	Ayar	*Lyonia ovalifolia* Wall. Drudge
16	Babool	*Acacia nilotica* (L.)Delile
17	Baheda, Bahera	*Terminalia bellirica* Roxb.
18	Bakain	*Melia azadirachta* L.
19	Bakli	*Anogeissus latifolia* Roxb. ex DC.
20	Bakul, Bullet wood	*Mimusops elengi* L.
21	Balamkheera	*Kigelia pinnata* (Jacq.) DC.
22	Baner	
23	Banjh	*Quercus leucotrichophora* Camus
24	Bans	*Dendrocalamus* sp.
25	Bargad, Bat	*Ficus benghalensis* L.
26	Bedu	
27	Bekal	*Pinsepia utilis* Royle.
28	Bael, Kauth Bael	*Aegle marmelos* L.
29	Ber, Ziziphus	*Ziziphus mauritiana* Jujube.
30	Betelnut	*Areca catechu* L.
31	Bhamora	*Benthamidia capitata* Wall. Hara
32	Bheemal	*Grewia optiva* Roxb.
33	Bottlebrush	*Callistemon lanceolatus*
34	Box Badam, Indian almond	*Sterculia foetida* L.
35	Burans	*Rhododendron arboreum* Smith.
36	Chakalta, Haldu	*Adina cordifolia* (Roxb.) Brandis
37	Chakundi	*Cassia siamea* Lam.
38	Champa	*Plumeria rubra* L.

S. No.	Vernacular name	Botanical name
39	Chamror	*Ehretia laevis* (Rottler ex G. Don) Roxb.
40	Chandan	*Santalum album* L.
41	Cheer	*Pinus roxburghii* Sarg.
42	Chikrashi	*Chukrasia tabularis* A. Juss.
43	Chilaha	
44	Chilmil	
45	Chirol, Challa, Chilbil, Kanju	*Holoptelea integrifolia* Roxb.
46	Chitwan, Chatim	*Alstonia scholaris* (L.) R. Br.
47	Christmas tree	*Araucaria columnaris* (JR Forst.) Hook.
48	Chukrasia	*Chukrasia tabularis* A. Juss.
49	Chuli	*Limnophyton obtusifolium* (L.)
50	Civic throne	
51	Croton	*Codiaeum variegatum* (L.) Rumph. ex A.Juss.
52	Dadim	*Punica granatum* Linn.
53	Daiyadana	*Callicarpa macrophylla* Vahl.
54	Devdar	*Cedrus deodara* Loud.
55	Dhak	*Butea monosperma* Lank.
56	Dhaula	*Morinda coreia* buch. Ham.
57	Doka	*Isoberlinia doka* Craib & Stapf
58	Dreacena	*Dracaena angustifolia* (Medik.) Roxb
59	Drumstick, Sajina	*Moringa oleifera* Lam.
60	Dumar	*Ficus racemosa* L.
61	Eucalyptus	*Eucalyptus grandis* W. Hill ex Maiden
62	Ficus benjamina	*Ficus benjamina* L.
63	Gadbhais	
64	Gajela	
65	Gamhar	*Gmelina arborea* Roxb. ex Sm.
66	Gingharu	*Pyracantha crenulata* D. Don.
67	Ginni	*Panicum maximum* Jacq.
68	Gular	*Ficus racemosa* L.
69	Gulmohar, Krishnachura	*Delonix regia* Hook. Raf.
70	Gunpowder Tree	*Trema orientalis* (L.)
71	Gutel	*Trewia nudiflora* Linn.
72	Haldu	*Adina cordifolia* Roxb.
73	Hararh	*Terminalia chebula* Retz.
74	Harra	*Terminalia chebula* Retz.
75	Harsingar	*Nyctanthes arbor-tristis* L.
76	Hisar	*Rubus lasiocarpus* Smith
77	Imli, Tetul	*Tamarindus indica* L.
78	Jacaranda	*Jacaranda mimosifolia* D. Don.

S. No.	Vernacular name	Botanical name
79	Jamrul	*Syzygium samarangense* (Blume) Merr. & L.M.Perry
80	Jamun, Jam	*Syzygium Cumini* L. Skeels.
81	Jarul	*Lagerstroemia speciosa* (L.) Pers.
82	Jhau	*Tamarix dioica* Roxb. ex Roth
83	Jiyal	
84	Jungle Jalebi, Jalebi	*Pithecellobium dulce* (Roxb.)Benth.
85	Junglee gulab	*Rosa acicularis* Lindley
86	Kaafal	*Myrica nagi* Thunb.
87	Kaat Badam, Bengal almond	*Terminalia catappa* L.
88	Kachnar, Kanchan, Orchid tree	*Bauhinia variegata* Linn.
89	Kadam	*Anthocephalus cadamba* (Roxb.)
90	Kadipatta	*Murraya Koenigii* L.
91	Kael	*Pinus wallichiana* ABJ.
92	Kaju	*Anacardium occidentale* L.
93	Kamini	*Murraya paniculata* (L.) Jacq.
94	Kanakchampa	*Pterospermum acerifolium* (L.)
95	Kanbakara	
96	Kangu	*Flacourtia indica* Merr.
97	Kans	*Saccharum spontaneum* Linn.
98	Kapur Kachri	*Hedychium spicatum* Smith
99	Karanj, Kanji	*Millettia pinnata* L.
100	Karonda	*Carissa spinarum* Linn.
101	Kasia	
102	Kat Sagaun	*Heterophragma adenophyllum*
103	Kathal	*Artocarpus heterophyllus* Lam.
104	Kaul	
105	Kedarpatti	*Skimmia laureola* Seib. Zucc.
106	Kekar	
107	Khair	*Acacia catechu* Willd.
108	Kharik, Khajur	*Artocarpus heterophyllus* Lam.
109	Kharsu	*Quercus semicarpifolia* Smith.
110	Khomani	
111	Kingoda, Kilmoda	*Berberis aristata* D. C.)
112	Kinu	*Citrus nobilis* x *Citrus deliciosa*
113	Korobi, Oleander, Kaner	*Nerium oleander*
114	Kuju	*Rosa macrophylla* Lindl.
115	Kund, Indian jasmine	*Jasminum multiflorum* (Burm.f.) Andrews
116	Kurchi	*Holarrhena pubescens* Wall. ex G.Don

S. No.	Vernacular name	Botanical name
117	Kusum	*Schleichera oleosa* (Lour.) Oken
118	Kutki	*Picrorhiza kurroa* Royle.
119	Lambu, East African mahogany	*Khaya senegalensis* (Desv.) A. Juss.
120	Lasoda	*Cordia dichotoma* Forst.
121	Litchi	*Litchi chinensis* Sonn.
122	Lodhu	*Symplocos chinensis* Lour.
123	Mahal	*Pyrus pashia* Buch-Ham.
124	Mahogany	*Swietenia mahagoni* (L.) Jacq.
125	Mahua, Mahul	*Madhuca longifolia* L. J. F. Macbr
126	Majnu	*Salix babylonica* Linn.
127	Malaysian Sal	*Shorea borneensis* Pierre
128	Malkand	
129	Malta	*Citrus sinensis* L.
130	Manipuri oak	*Quercus serrata* Murray
131	Marodphali	*Helicteres isora* L.
132	Mat tea	
133	Mehandi	*Lawsonia inermis* L.
134	Minjiri	*Senna siamea* (Lam.) H.S.Irwin & Barneby
135	Molshree	*Mimusops elengi* Linn.
136	Morpankhi	*Platycladus orientalis* (L.)
137	Moru	*Quercus floribunda* Rehdr.
138	Mourinda	*Abies pindrow* Spach.
139	Murga, Piyasal, Pistal	*Pterocarpus marsupium* Roxb.
140	Mussaenda, Bangkok rose	*Mussaenda erythrophylla* Schumach. & Thonn.
141	Nag Champa	*Plumeria pudica* Jacq.
142	Napier	*Pennisetum purpureum* Schumach.
143	Neem	*Azadirachta indica* A. Juss
144	Nirgundi	*Vitex negundo* L.
145	Paakad	*Ficus virens* Aiton.
146	Pachnola	*Butea monosperma* Lam. Taub.
147	Padadiya	
148	Padam	*Prunus cerasoides* D. Don
149	Padang	*Cinnamomum burmannii* (Nees & T.Nees) Blume
150	Palash	*Butea monosperma* (Lam.) Taubert
151	Pangar	*Aesculus indica* Colebr.
152	Papdi	*Buxus wallichiana* Baill.
153	Peeliya, Yellow trumpetbush	*Tecoma stans* L.
154	Peepal	*Ficus religiosa* L.
155	Pila Gulmohar, Radhachura	*Peltophorum pterocarpum* (DC.) K.Heyne

S. No.	Vernacular name	Botanical name
156	Piyal	*Buchananania lanzan* Spreng.
157	Plumeria alba, White Frangipani	*Plumeria alba* L.
158	Prosopis, vilayati babul	*Prosopis juliflora* (Sw.) DC.
159	Putrajeeva	*Putranjiva roxburghii* Wall.
160	Raffix palm	*Rhapis excelsa* (Thunb.) A.Henry
161	Rain tree	*Samanea saman* (Jacq.) Merr.
162	Raktachandan	*Pterocarpus santalinus* L.f.
163	Reetha	*Sapindus mukorossi* Gaertn.
164	Ringal	*Thamnocalamus falconeri* Hook. F.
165	Rohini	*Mallotus philippinensis* Muellary
166	Rudrapalash	*Spathodea campanulata* Beauv.
167	Runiya	
168	Ryi	*Picea smithiana* Boiss.
169	Sagaun	*Tectona grandis* Linn.
170	Sain	*Terminalia tomentosa* Mart.
171	Sal	*Shorea robusta* Gaertn.
172	Salparni	*Desmodium gangeticum* L. DC.
173	Sandan	*Ougeinia oojeinensis* Roxb. Hoch.
174	Satavar	*Asparagus racemosus* Royle.
175	Seb	*Pyrus malus* Linn.
176	Semal, Simul	*Bombax ceiba* Linn
177	Semla	*Bauhinia semla* Roxb.
178	Shahtoot	*Morus alba* Linn.
179	Sheesham, Shishu	*Dalbergia sissoo* Roxb.
180	Shiuli	*Nyctanthes arbor-tristis* L.
181	Shivali	
182	Silver oak	*Grevillea robusta* A. Cunn. ex R. Br.
183	Siris	*Albizia julibrissin* Durazz.
184	Subabool	*Leucaena leucocephala* (Lam.)de Wit
185	Surai	*Cupressus torulosa* D.Don
186	Tabebuia	*Tabebuia rosea* (Bertol.) DC.
187	Tecoma	*Tecoma stans* (L.) Juss. ex Kunth
188	Tejpatta	*Cinnamomum tamala* Fr. Nees.
189	Tendu	*Diospyros melanoxylon* Roxb.
190	Thespesia, Indian Tulip	*Thespesia populnea* (L.) Sol. ex Corrêa
191	Timla	*Ficus auriculata* Lour.
192	Timru	*Zanthoxylum armatum* DC.
193	Totaplant/ Mandar	*Erythrina variegata* Linn.
194	Tun	*Toona ciliata* Roem.

S. No.	Vernacular name	Botanical name
195	Tungla	*Rhus parviflora* Roxb.
196	Tushari	*Debregeasia salicifolia* Roxb. D. Don
197	Utis	*Alnus nepalensis* D. Don

10.3 List of plantation models in different states and landscapes

I- Natural Landscape			
A. Hills			
State	**Model Type**	**Model**	**Brief Description**
Uttarakhand	Alpine Meadows Conservation	NL/H/01	Conservation practices prescribed in Working Plans of the respective Forest Divisions will be applied to conserve native biodiversity. Medicinal plant species will be planted at the rate of 200 patches/ha in blanks.
	Sub-Alpine Conservation	NL/H/02	Conservation practices prescribed in Working Plans of the respective Forest Divisions will be applied. Medicinal plant species will be planted at the rate of 200 patches/ha in blanks.
	Temperate Conifer Forest	NL/H/03	Planting of 400 tree or bamboo, 400 shrub, 200 medicinal plants and 200 grass and sedges will be carried out per hectare.
	Temperate Mixed Forest	NL/H/04	Planting of 400 tree or bamboo, 400 shrub, 200 medicinal plants and 200 grass and sedges will be carried out per hectare.
	Temperate Broadleaved Forest	NL/H/05	Planting of 400 tree or bamboo, 400 shrub, 200 medicinal plants and 200 grass and sedges will be carried out per hectare.
	Moist Temperate Broadleaved Forest	NL/H/06	Planting of 400 tree or bamboo, 400 shrub, 200 medicinal plants and 200 grass and sedges will be carried out per hectare.
	Himalayan Chir Pine Forest	NL/H/07	Planting of 400 tree or bamboo, 400 shrub, 200 medicinal plants and 200 grass and sedges will be carried out per hectare.
	Upper Sub-tropical Dry Deciduous Forest	NL/H/08	Planting of 400 tree or bamboo, 400 shrub, 200 medicinal plants and 200 grass and sedges will be carried out per hectare.
	Lower Sub-tropical Dry Deciduous Forest	NL/H/09	Planting of 400 tree or bamboo, 400 shrub, 200 medicinal dry plants and 200 grass and sedges will be carried out per hectare.

	Control/Removal of Invasive Species	NL/H/10	It is planned to cut and uproot invasive species in these areas which may followed by plantation of native plants.
	Plantation by Eco-task Force	NL/H/11	Exceptionally difficult sites having problems like steep slopes, shallow soil and excessive threats from biotic and abiotic agencies which required continued close supervision will be identified. Establishment and maintenance of plantation on such sites will be carried out by existing unit(s) of Eco Task Force in close coordination with Uttarakhand State Forest Department
West Bengal	Miscellaneous Species Plantation	NL/H/12	Separate pure blocks of 40 m x 20 m size will be created for different species. Few blocks would be planted with rare and endangered species including cane. (1600 plants/ha)
	Grass and Fodder Tree Plantation	NL/H/13	Grass slips will be put at 1 m x 1 m spacing Tree (10,000 plants/ha) and in some plots, fodder tree seedlings will be planted at 10 m x 10 m spacing (100 plants/ha).
	Under planting with Bamboo	NL/H/14	After canopy-opening of plantation areas in sanctuaries, bamboo seedlings will be under planted at 4 m x 4 m spacing (625 plants/ha) and in some plots, fruit tree seedlings will be planted at 10 m x 10 m spacing (100 plants/ha).
B. Ganga Plains			
Uttar Pradesh	Tree – Shrub – Medicinal Plant	NL/P/01	This model will be implemented in *khadar* area. 625 plants of trees/shrubs, 400 patches of grasses/sedges and 200 plants of medicinal plant species per hectare will be planted.
	Grass – Bamboo – Tree	NL/P/02	This model will be implemented in *khola* area with plain topography. 625 plants of trees + bamboos and 1000 patches of grasses per hectare will be planted.
	Grass – Shrub – Tree – Medicinal Plant	NL/P/03	This model will be implemented in *khola* area with undulating topography. 400 plants of trees, 400 plants of shrubs, 400 patches of grasses and 200 plants of medicinal plant species per hectare will be planted.
	Plantation by Eco-task Force	NL/P/04	Exceptionally difficult sites having problems like shallow soil and excessive threats from biotic and abiotic agencies which required continued close supervision will be identified. Establishment and maintenance of plantation on such sites will be carried out by existing unit(s) of Eco Task Force in close coordination with Uttarakhand State Forest Department
Bihar	Block Forest Plantation	NL/P/05	435 pits per ha of size 0.45 m x 0.45 m x 0.45 m will be dug and 190 mounds per ha of 2.10 m x 0.75 m x

			0.60 m size will be prepared. Trees will be planted in blocks at the rate of 625 trees per ha at 4 m x 4 m spacing.
	Bamboo Gabion Linear Mixed Species plantation	NL/P/06	Bamboo tree guards of 2.1 m x 0.6 m x 0.6 m size will be constructed and installed at the rate of 300 gabions per ha. Planting will be done in pits of size 0.45 m x 0.45 m x 0.45 m at the rate of 300 plant per ha.
	Iron Gabion Linear Mixed Species Plantation	NL/P/07	Iron tree guards of size 1.5 m x 0.6 m will be constructed and installed at the rate of 100 gabions per ha. Planting will be done in pits of size 0.45 m x 0.45 m x 0.45 m at the rate of 300 plant per ha.
	Linear Mixed Species Plantation Without Gabion	NL/P/08	Mounds of size 2.60 m x 1.00 m x 0.60 m will be prepared at Plantation Without Gabion the rate of 500 mounds per km at a spacing of 4 m per row in two rows along the road.
	Canalside Linear Mixed Species Plantation	NL/P/09	500 mounds per km of size 2.60 m x 1.00 m x 0.60 m will be prepared. Planting will be done at a density of 500 plants per km at a spacing of 4 m per row in two rows along the canal.
	Riverside Linear Mixed Species Plantation	NL/P/10	500 mounds per km of size 2.60 m x 1.00 m x 0.60 m will be prepared. Planting will be done at a density of 500 trees per km at a spacing of 4 m per row in two rows along the river.
Jharkhand	Mixed Species Strip Plantation	NL/P/11	The planting area will be cleaned and grass slips may be put at 1 m x 1 m spacing in the inner most fence towards the river bank. Plantation of water-loving species in few rows followed by fast-growing species in the outermost row is proposed. Planting shall be done on 60 cm high mounds (1,500 mounds per ha).
West Bengal	Sal and Associate Species	NL/P/12	Six rows of Sal and four rows of miscellaneous associates will be planted to raise blocks. Associates will be planted in groups (preferably 160 – 400 plants per species) in each block. Planting will be done at a density of 1,600 plants per ha at 2.5 m x 2.5 m spacing.
	Quick Growing Small Timber, Fuel and Fodder Plantation	NL/P/13	The major plantation species will be planted in blocks to occupy 70% area and blocks of miscellaneous spp. will occupy 30% area. Blocks may be contiguous having 1,600 plants per ha at spacing 2.5 m x 2.5 m. Within the block of miscellaneous spp., pure sub-blocks of each species comprising 160 to 400 plants will be planted.
	Restoration of Degraded Forest	NL/P/14	Dead, dying, moribund, bent and suppressed coppice shoots of Sal will be cut, hoeing will be done around the living stump, and mulch, manure and

			insecticide will be applied. Live hedge will be raised along with fence of bamboo posts.
	Multiple Shoot Cutting	NL/P/15	Quality shoots on a stump will be marked and the remaining shoots will be removed to improve tree form and wood quality.
	Riverbank Afforestation	NL/P/16	Grasses or surface growers will be allowed to cover and bind the surface soil. Small and medium sized herbs and shrubs will be accommodated as the second layer of vegetation.
	Mangrove Afforestation	NL/P/17	Mangrove plantation in coastal areas will be done for (i) restoration of degraded areas, and (ii) bringing under forest cover the newly accreted stabilized mudflats.
	Eradication of Invasive Species and Restoration of Mangroves	NL/P/18	Non-mangrove species will be cut and uprooted in mangrove areas and the area will be restored by planting of mangrove species.
II – Agriculture Landscape			
Uttarakhand	Planting of Economic Trees in Hills	AL/H/01	This model will be implemented in agriculture land in temperate, Sub-Temperate and Sub-Tropical Zones in Uttarakhand.
Uttar Pradesh, Bihar, Jharkhand	Planting of Economic Trees in Plains	AL/P/01	Economic tree species (including bamboos) will be planted on agriculture land. Tree planting may be done on one or more bunds or throughout the field as well as in areas near rural houses, farms etc.
West Bengal	Distribution of Plants of Fruit Trees	AL/P/02	This model will be implemented in Gangetic plains of West Bengal. Plants of fruit trees will be distributed to farmers for planting on agriculture land. Planting will be done by the farmers in areas near rural houses, farms etc.
III – Urban Landscape			
Uttarakhand and Uttar Pradesh	Bioremediation and Biofilteration	UL/B/01	The model will have the following activities: (1) Waste water treatment through mechanical measures (2) Biofilters may be of the following types: Free floating macrophyte biofilter, emergent macrophyte biofilter, sub merged macrophyte biofilter, multispecies algal biofilter.
Uttarakhand, Uttar Pradesh, Bihar and West Bengal	Riverfront Development	UL/R/01	The proposed model of riverfront development would involve plantation along the riverbank to stabilize the soil and protect the bank from soil erosion. In addition to it, need-based activities will be undertaken to generate awareness and provide a pleasing and relaxing environment to the visitors.
Uttarakhand, Uttar Pradesh,	Eco-park Development	UL/E/01	An eco-park will have better facilities than riverfront development to facilitate the visitors. The

Bihar and West Bengal			proportion of ornamental plants will be relatively more than in the riverfront development model.
Uttarakhand, Uttar Pradesh, Jharkhand and West Bengal	Institutional and Industrial Estate Plantation	UL/I/01	Mainly ornamental, shade and fruit plants will be encouraged for planting under this model. Evergreen plants will be preferred so that leaves do not shed during winters when air pollution is usually higher.
Uttarakhand, Uttar Pradesh and West Bengal	Avenue Plantation	UL/A/01	Urban areas falling within the treatment zone may be taken up for establishing avenue plantations. These plantations will consist of short or medium sized trees on both sides of the road.

Source: Adapted from FRI DPR (2016)