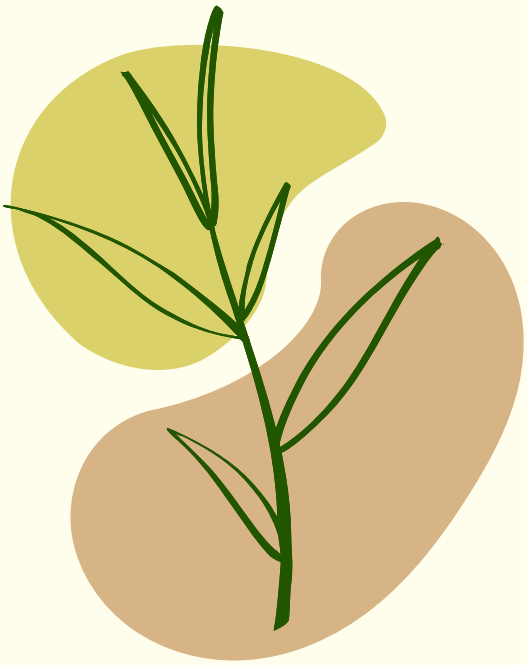
Urban Forests

Comprehensive Guidelines for Establishing Micro-forests

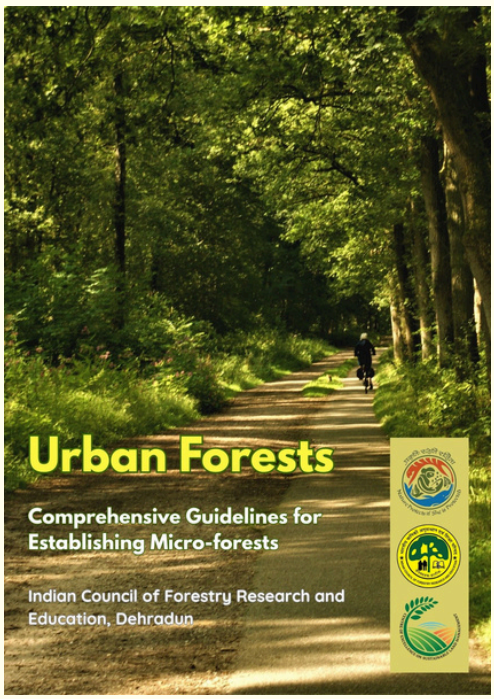
Indian Council of Forestry Research and Education, Dehradun

Urban Forests



Comprehensive Guidelines for Establishing Micro-forests

Indian Council of Forestry Research and Education
Dehradun



Chief Patron
Smt. Kanchan Devi, IFS
Director General, Indian Council of Forestry Research and Education (ICFRE)

Patron
Sh. Vinay Kumar, IFS
Director International Cooperation & Centre of Excellence on Sustainable Land Management (CoE-SLM), ICFRE

Editor
Sh. Sanjeev Kumar, Scientist-F
Centre of Excellence on Sustainable Land Management, ICFRE

Technical Support
Dr. Tanay Barman, Research Associate, CoE-SLM, ICFRE
Sh. Ajay Chauhan, Research Associate, CoE-SLM, ICFRE
Dr. Arpit Huria, Research Associate, CoE-SLM, ICFRE
Dr. Ashish Krishna Yadav, Research Associate, CoE-SLM, ICFRE

Citation
ICFRE, 2025. Urban Forests: Comprehensive Guidelines for Establishing Micro-forests, Indian Council of Forestry Research and Education, Dehradun, India.

Published by
Indian Council of Forestry Research and Education
P.O. New Forest, Dehradun-248006, Uttarakhand, India

कंचन देवी, भा.व.से.
Kanchan Devi, IFS

कुलाधिपति, व.अ.स. विश्वविद्यालय
Chancellor, FRI University

महानिदेशक
भारतीय वानिकी अनुसंधान एवं शिक्षा परिषद्
न्यू फॉरेस्ट, देहरादून-248006
(आई.एस.ओ. 9001:2008 प्रमाणित संस्था)
Director General
Indian Council of Forestry Research and Education
P.O. New Forest, Dehra Dun-248 006
(An ISO 9001:2008 Certified Organisation)

Message

Urbanization and the rapid spread of grey infrastructure are causing a significant decline in green spaces, affecting urban ecosystems, human health, and biodiversity. Fragmented habitats, pollution, extreme temperatures, and frequent heatwaves pose major environmental and social challenges. To counter this, there is a growing need to restore ecological balance in cities through nature-based solutions. One such solution is the creation of dense, native micro-forests—compact, biodiverse green patches that revitalize degraded urban land, improve climate resilience, and enhance urban living conditions.

Rooted in ecological restoration principles, urban micro-forests are created using the Miyawaki Plantation methodology and rely on indigenous species to mimic natural forest structures. When carefully designed, they become self-sustaining ecosystems that enhance biodiversity, sequester carbon, reduce heat island effects, and support community greening efforts. These forests align with India's goals for Land Degradation Neutrality (LDN), climate action, and sustainable development.

In line with this vision, the Indian Council of Forestry Research and Education (ICFRE) has developed Urban Forests: Comprehensive Guidelines for Establishing Micro-forests. This guide is intended for urban planners, institutions, forest departments, and citizen groups. It offers a step-by-step, scientifically grounded approach, enriched by field-tested insights from ICFRE's extensive research.

This manual is a valuable tool for promoting greener, more resilient cities. I commend the team behind its development and hope it inspires broader efforts toward sustainable urban transformation.

(Kanchan Devi)

दूरभाष/ Phone: 0135-2759382 (O)
EPABX: 0135-2224855, 2224333 (O)
ई-मेल/e-mail: dg@icfre.org

विनय कुमार, भा.व.से.
Vinay Kumar, IFS

निदेशक (अंतर्राष्ट्रीय सहयोग)
भारतीय वानिकी अनुसंधान एवं शिक्षा परिषद्
न्यू फॉरेस्ट, देहरादून-248006
(आई.एस.ओ. 9001:2008 प्रमाणित संस्था)

Director (International Cooperation)
Indian Council of Forestry Research and Education
P.O. New Forest, Dehra Dun-248 006
(An ISO 9001:2008 Certified Organisation)

Foreword

Urban areas today face mounting ecological challenges due to expanding infrastructure and shrinking green spaces. The degradation of native habitats, declining biodiversity, deteriorating air and water quality, and increased exposure to climate extremes highlight the urgent need for restorative, nature-based interventions. Among the most effective strategies is the development of dense native micro-forests—small, biodiverse ecosystems designed to thrive in urban settings.

These forests, when established using indigenous species and scientific methods, offer multiple ecological and social benefits. They restore degraded land, enhance local biodiversity, sequester carbon, moderate urban temperatures, and reduce runoff. In addition, they create green spaces for community interaction, environmental learning, and improved well-being. Their potential aligns with national and global frameworks, including the UN Decade on Ecosystem Restoration, the Sustainable Development Goals, and India's climate and land restoration commitments under the UNCCD and Paris Agreement.

With this vision, the Indian Council of Forestry Research and Education (ICFRE) has developed Urban Forests: Comprehensive Guidelines for Establishing Micro-forests. This manual is a practical, research-based guide designed for municipalities, academic institutions, civil society organizations, and other stakeholders working to integrate green infrastructure into urban planning.

I acknowledge with appreciation the valuable contributors and editorial team for their dedicated efforts in developing this resource. Their work reflects a shared commitment to ecological restoration and sustainable urban living, and this manual will serve as a valuable tool for building greener, healthier, and more resilient cities.

(Vinay Kumar)

Sanjeev Kumar
Scientist-F
Centre of Excellence on Sustainable Land Management
Indian Council of Forestry Research and Education
Ministry of Environment, Forest and Climate Change
Government of India

The unprecedented pace of urban expansion has transformed natural landscapes into densely built environments, leading to widespread habitat loss, ecological fragmentation, and a decline in native biodiversity. Urban areas, once interspersed with green spaces, are increasingly devoid of natural vegetation, contributing to rising temperatures, poor air quality, and reduced ecosystem services. Amid these challenges, the restoration of ecological functions within cities has emerged as a scientific and practical imperative.

The concept of dense native micro-forests presents a highly effective nature-based solution for ecological restoration in urban and peri-urban settings. By utilizing native species and replicating natural forest dynamics at a small scale, these forests provide critical ecological benefits, including enhanced carbon sequestration, microclimate regulation, groundwater recharge, and biodiversity conservation. They also offer social and psychological advantages by creating accessible green spaces that promote environmental awareness and community engagement.

This manual, Urban Forests: Comprehensive Guidelines for Establishing Micro-forests, has been developed to provide comprehensive technical guidance for planning, establishing, and maintaining small-scale urban forests using native flora. The methodology outlined herein draws on research findings, ecological principles, and successful models demonstrated by the Indian Council of Forestry Research and Education (ICFRE) and its partner institutions across diverse urban contexts. The manual is designed to support a broad spectrum of stakeholders—including urban planners, municipal authorities, academic institutions, resident welfare associations, and civil society organizations—in mainstreaming urban greening as a tool for climate adaptation and ecosystem restoration. It also aligns with India's commitments to Land Degradation Neutrality (LDN), the Sustainable Development Goals (SDGs), and international frameworks for ecosystem restoration.

Scientific research, when translated into practical application, can drive meaningful change on the ground. I believe this publication will serve as a valuable reference for integrating ecological science into urban design and management. My sincere appreciation goes to all contributors and editorial members whose work made this compilation possible.

(Sanjeev Kumar)

Preface

Contents

Chapter 1: Introduction

In India, forest tree plantations are being actively encouraged through a range of central government schemes, state forest departments, and other organizations. The National Forest Policy of 1988 sets a target of bringing 33% of the country's geographical area under forest and tree cover. As per the Forest Survey of India (2023), the current forest and tree cover stands at 8,27,365.95 sq. km, accounting for 25.17% of the nation's total land area. In India, the population is growing very rapidly, especially in urban regions, hence, there is an urgent need for well-planned, sustainable management of forest to protect its resources from over-exploitation and degradation.

Forests in urban areas are rapidly declining due to expanding infrastructure, population growth, and land-use change. The green cover in cities is often fragmented and limited, leading to reduced biodiversity, poor air quality and increased urban heat. Urban forests, though scarce, play a crucial role in enhancing ecological balance by sequestering carbon, supporting wildlife and improving mental well-being. Efforts like urban greening, Micro-forest plantations and rooftop gardens are gaining momentum to combat environmental degradation. However, policy intervention, community participation and sustainable urban planning are essential to restore and preserve forest cover within city landscapes for future resilience and liability. As of March, 2011, India's urban population stood at 377.1 million out of a total of 1210.2 million, representing 31.6% of the population. Urban areas have seen a net increase of 91 million people over the previous decade, highlighting the growing pressure on urban ecosystems and the importance of integrating green cover into urban planning.

Aiming to boost forestation, promote urban greening and fulfill global sustainability targets, the Micro-forest method of plantation has emerged as a widely recommended and impactful approach to urban afforestation. Developed by the renowned Japanese botanist Dr. Akira Miyawaki, this method—often referred to as the Miyawaki Method—is a scientifically grounded and community-friendly afforestation technique that has gained international recognition for its ability to rapidly restore native vegetation and rehabilitate degraded or barren lands.

Unlike conventional plantation methods that often involve monocultures and require decades to mature, the Micro-forest technique mimics natural forest succession by planting a dense mix of indigenous species in a compact area. The process includes careful site preparation, species selection based on local ecology, and planting of multiple native species to simulate a multilayered forest structure.

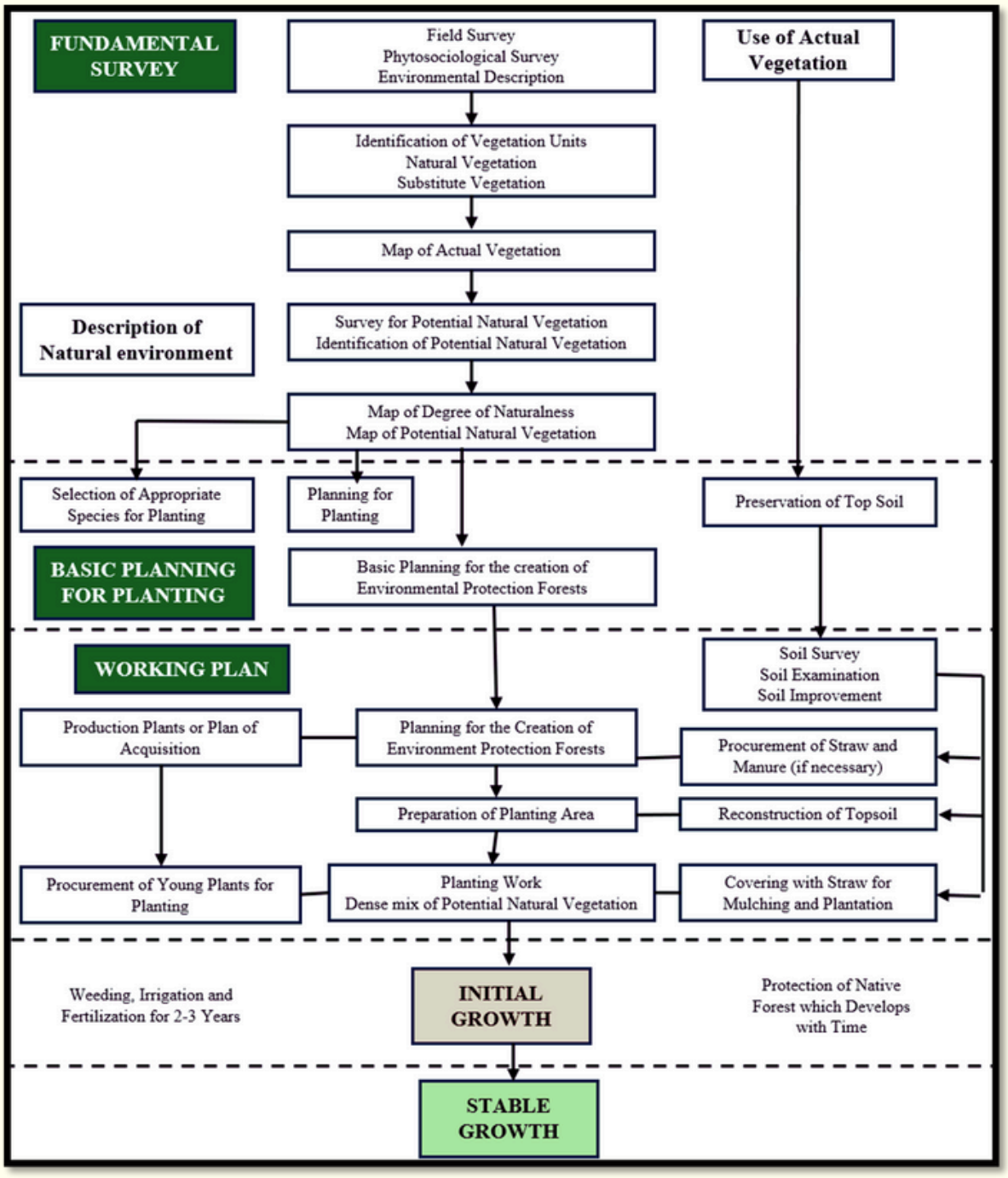
This accelerated growth not only jumpstarts forest development but also boosts vital ecosystem services like carbon capture, groundwater recharge, air purification and cooling. Micro-forests support remarkably high biodiversity—often surpassing that of conventional green spaces—by attracting a variety of birds, insects and microorganisms.

Thanks to their compact size, rapid impact, and adaptability, Miyawaki forests are ideal for urban areas, campuses, industrial sites, and degraded land. They offer a hands-on model for ecological restoration, engaging communities, students and volunteers in the process.

Amid growing climate and land degradation challenges, the Micro-forest method offers a scalable, nature-positive solution. It aligns well with global and national restoration goals, including the UN Decade on Ecosystem Restoration (2021–2030), making it a powerful tool for building resilient, biodiverse landscapes.

1.1 Principles of Micro-forest

Micro-forest is created by using the Miyawaki plantation methodology. The core concept behind the Micro-forest is planting tree species that are naturally found in a specific region and work synergistically to form a rich, multi-layered forest ecosystem. This approach ensures the restoration of native forests using indigenous species that support and enhance each other's growth. Initially guided by the idea of potential natural vegetation (PNV)—the plant life that would naturally thrive in an area without human interference—the method emphasizes ecological authenticity. A key characteristic of Micro-forest is the extremely high planting density, simulating natural regeneration when canopy gaps appear. This drives rapid upward growth as saplings compete for sunlight, and natural selection favours the strongest, accelerating forest formation within 20–30 years rather than centuries. This rapid development is especially valuable for initiatives focused on increasing carbon capture and rebuilding wildlife habitats.



Flow chart for the restoration and creation of micro-forest (Source: Miyawaki, 1999)

1.2 History

The Miyawaki method is named after its founder, Late Dr. Akira Miyawaki, a Japanese botanist and plant ecologist with a deep interest in phytosociology—the study of interactions among plant species within communities. After earning his PhD in plant ecology, Miyawaki studied under German phytosociologist Reinhold Tüxen, where he was introduced to the concept of potential natural vegetation (PNV). On returning to Japan, he applied PNV concepts to local landscapes and became intrigued by the remnants of ancient sacred forests near shrines and temples, known as Chinju-no-mori. These groves featured native species like Japanese blue oak, chestnut and Sakaki, in contrast to the widespread conifer plantations of non-native species like larch and cedar. These sacred groves also displayed a complex, layered forest structure, with canopy trees, sub-trees, shrubs and ground plants. By integrating PNV insights with this understanding of native forest layering, Miyawaki developed a novel method for forest creation that mimics natural ecosystems. His early experiments demonstrated the method's potential to rapidly foster biodiverse, stable forests.

Late Dr. Akira Miyawaki

Dr. Akira Miyawaki was a renowned Japanese botanist and expert in plant ecology born in Okayama, Japan, on January 29, 1928, best known for developing the Miyawaki Method of afforestation. He served as a visiting researcher at the Federal Institute for Vegetation Mapping in West Germany from 1958 to 1960. He emphasized the use of native species to restore natural forests on degraded land in a short time.

His method promotes dense, fast-growing and self-sustaining forests that mimic natural ecosystems. Dr. Miyawaki's work has contributed significantly to biodiversity conservation, climate change mitigation and urban greening across the globe. forest creation. He received several international awards for his pioneering work, including the Asahi Shimbun Prize (1990), the Reinhold Tüxen Prize, Germany (1995), the Order of the Sacred Treasure, Gold and Silver Star, Japanese Government (2000), the Blue Planet Prize (2006) and many others. Dr. Miyawaki's pioneering approach to native forest restoration has ignited a global movement for ecological healing. His legacy lives on through community-driven efforts that transform degraded lands into thriving green ecosystems.

1.3 Significance of Micro-forest

Micro-forest play a crucial role in combating environmental degradation, climate change, and the decline of biodiversity. By utilizing native plant species and imitating natural forest dynamics, they help restore ecological harmony and sustain diverse plant and animal life. Their quick growth and compact planting enhance their ability to absorb carbon, purify air and water and mitigate urban heat. Once established, these forests need little upkeep and can flourish even in confined urban areas. They are instrumental in fostering human-nature connections, advancing sustainable development and supporting international initiatives focused on ecological restoration and climate adaptation.

Miyawaki plantation

1.4 Comparison between the Micro-forest method and Traditional Plantation methods

Feature	Micro-forest	Traditional Plantation
Species selection	Native, site-specific species based on Potential Natural Vegetation (PNV)	Often monocultures or commercially valuable species
Planting density	Very high (3–5 saplings/m²)	Low to moderate
Growth rate	Fast – forests mature in 20–30 years	Slow – may take 100+ years to mature
Biodiversity	High – multiple layers and native species	Low – limited species diversity
Maintenance	Low after 2–3 years – becomes self-sustaining	Requires ongoing care (weeding, watering, pesticides, etc.)
Carbon sequestration	High – due to dense planting and fast growth	Moderate to low
Urban suitability	Excellent – can be planted in small or confined spaces	Less suitable for dense urban areas
Soil enrichment	Enhanced naturally via leaf litter and microbial activity	Often relies on external inputs like fertilizers
Ecosystem value	Restores natural forest ecosystems	Offers limited ecosystem services

Chapter 2: Site Selection

The selection of a suitable site is one of the most critical steps in the process of establishing a successful forest plantation. It serves as the foundational stage upon which the entire plantation programme is built. A well-chosen site not only supports the healthy growth of trees but also enhances the overall effectiveness of the plantation initiative in meeting its ecological, environmental and social objectives. In methods like the Micro-forest technique, which require intensive planting and rapid ecosystem development, the importance of proper site selection becomes even more pronounced.

2.1 Significance of selecting the right site

It is a thoughtful and scientific process that requires evaluating a variety of physical, ecological and logistical factors. A carefully selected site allows planners to make informed decisions regarding what species should be planted, how the land should be prepared and what infrastructure will be needed to support the plantation in both short and long term. Proper site selection is vital for the success of micro-forests, as it directly influences plant survival, growth rate, and ecosystem development. Choosing a site with suitable soil, adequate sunlight, good drainage and water availability ensures that native species can thrive with minimal intervention. It also reduces long-term maintenance needs and enhances the ecological impact by supporting faster forest formation and greater biodiversity in a small area. Selecting an appropriate site is the most crucial step in establishing a successful micro forest criteria of selection a site are as:

- **Soil**: Good soil supplies moisture, provides nutrients and supports the tree physically.
- **Soil quality:** Well-drained, fertile, and organic material rich are the ideal soils. If the site's soil doesn't meet these criteria, it needs improvement using compost or organic matter.
- **Size of the plot:** Sites can range from as small as 100 sq. m. to larger patches up to 1000 sq. m. Even small urban pockets like roadside strips, school campuses, housing society corners, or vacant municipal lands can be used for creation of micro-forest.
- **Accessibility:** The location should be easily accessible for transportation of materials, planting, watering and long-term maintenance.
- **Sunlight availability:** A site with good exposure to sunlight (ideally 6–8 hours per day) is essential, especially during the early stages of plant growth.
- **Water availability:** Adequate water must be available either through natural sources or artificial irrigation to support initial establishment and maintenance of the micro-forest.
- **Protection from disturbance:** Choose sites that are not prone to frequent human or animal disturbance. If near settlements exist, proper fencing or barriers should be planned.
- **Topography and drainage:** Sites with slight slopes are acceptable, but water should not stagnate. Proper drainage must be ensured to avoid root rot or waterlogging.
- **Potential for community engagement:** Preference should be given to sites where local communities, schools or institutions can participate and take ownership in maintenance.
- **Legal and land use status:** Ensure there are no legal disputes or development plans for the land. Ownership, permission and long-term protection must be verified.

2.2 Steps for selection of site

Selecting an appropriate site is crucial for the success of a micro-forest plantation. Following steps are taken for selecting the appropriate site:

Identify available land
↓
Check legal status & ownership
↓
Assess accessibility (for materials & maintenance)
↓
Evaluate sunlight availability (6–8 hrs/day)
↓
Test soil quality (texture, fertility, drainage)
↓
Check water availability (irrigation or source)
↓
Examine topography & drainage conditions
↓
Ensure protection from human/animal disturbance
↓
Evaluate community engagement potential
↓
Finalize site selection

Chapter 3: Selection of Species

The selection of appropriate tree species is a cornerstone of the Micro-forest method of afforestation. This process directly influences the success, structure and ecological function of the forest that develops. Since the Micro-forest technique seeks to replicate native, multi-layered forest ecosystems in a condensed time frame, it is essential that the selected species are ecologically suitable and representative of the region's natural vegetation. Selecting species that are not adapted to the site conditions or are ecologically incompatible, can result in poor growth, competition failures and an inability to form the desired forest stratification. Thus, species selection must be grounded in ecological research and site-specific studies. The role of canopy development is particularly critical in a Micro-forest plantation. As the forest matures, the upper canopy influences microclimatic conditions within the plantation.

This includes regulation of light penetration, moisture levels, air humidity, and even localized temperature and rainfall retention. These factors collectively influence the growth and development of plant species at various forest strata. If the top canopy is dominated by inappropriate or non-native species, it may suppress the development of lower and middle storey vegetation, thereby disturbing the ecological balance of the plantation. The Micro-forest approach views the forest as a tightly-knit community where every layer supports the others. Just as leadership sets the tone in human communities, the dominant tree layer shapes the health and structure of the entire ecosystem (Lewis, 2022).

3.1 Significance of selecting the right species

Proper species selection is a cornerstone of successful micro-forest development, as it ensures ecological harmony, structural diversity and long-term sustainability.

By selecting native and locally adapted species that naturally coexist, planners can replicate the layered structure of natural forests canopy, sub-canopy, shrubs, and ground cover within a short time frame. This enhances biodiversity, supports natural ecological functions, and promotes resilience against pests, drought, and climate variability. Inappropriate species selection, on the other hand, can lead to competition failures, poor growth, and an imbalance in forest structure. Therefore, careful species selection based on site-specific conditions, ecological compatibility, and the concept of Potential Natural Vegetation (PNV) is essential for creating a self-sustaining, dense, and vibrant forest ecosystem.

Careful selection of plant species is fundamental to the success of micro forests. This technique emphasizes the creation of dense, multi-layered native forests that replicate natural ecosystems. Therefore, selecting species that are native, ecologically compatible, and suited to local site conditions is critical.

The following key points suggest the species selection process:

- **Native and indigenous species:** Prioritize species that are naturally found in the local area. These plants are well adapted to the region’s climate, soil, and ecological interactions.
- **Multi-layered forest structure:** Choose species that represent different vertical layers of the forest—canopy (tall trees), sub-canopy (medium-sized trees), shrub layer, and ground cover—to mimic a natural forest ecosystem.
- **Ecological compatibility:** Select species that can coexist without competing aggressively. They should have similar water, light and nutrient requirements.

- **Phytosociological survey:** Conduct field-based vegetation surveys in nearby natural areas or undisturbed forest patches to identify species that naturally grow together in communities.
- **Potential Natural Vegetation (PNV):** Refer to the concept of PNV to identify species that represent the climax vegetation of the area under current ecological conditions.
- **Growth characteristics:** Prefer species with rapid growth, deep roots and strong adaptability. Avoid species with strong allelopathic effects that may inhibit the growth of neighbouring plants.
- **Resilience and sustainability:** Select a mix of species that can withstand local stresses such as drought, pests, or seasonal changes, ensuring the forest matures into a self-sustaining ecosystem.
- **Cultural and ecological Value:** Include species that have traditional, medicinal, or ecological importance to increase community interest and biodiversity value.

3.2 Steps for selection of species

Conduct Field Vegetation Survey
↓
Prepare List of Native/Indigenous Species
↓
Apply Phytosociological Methods
↓
Group Species by Forest Layers:
Canopy (Tall trees)
Sub-Canopy (Medium trees)
Shrubs
Ground Cover
↓
Cross-Check with Potential Natural Vegetation (PNV)
↓
Assess Ecological Compatibility (light, water needs)
↓
Evaluate Growth Traits (root depth, resilience)
↓
Avoid Invasive or Allelopathic Species
↓
Incorporate Culturally/Ecologically Valuable Species
↓
Finalize Species List for Plantation

Low fertility, decreased organic matter, poor structure and poor water retention are common characteristics of degraded soils that render them unsuitable for supporting plants. Without plant cover, erosion is accelerated, and microbial activity and root development are impeded by compaction and inadequate drainage. Micro-forest plantings restore environments by enhancing soil health and establishing dense, diverse native forests. Successful establishment begins with fencing, site preparation and soil enrichment using biomass, compost and microbiological treatments, followed by careful planting, mulching and ongoing maintenance.

4.1 Fencing

Where there is much biotic pressure, fencing is the first and essential step before plantation. It plays a crucial role in protecting young saplings from grazing animals, human interference and other external disturbances, while also clearly demarcating the plantation boundary. Selecting the appropriate type of fencing depends on local conditions, availability of materials, cost and long-term maintenance considerations. The commonly used types of fencing include:

- **Barbed-wire fencing:** One of the most widely used methods, barbed-wire fencing involves stretching galvanized steel wire with sharp barbs between wooden, iron, or concrete posts. It offers a durable and cost-effective solution, especially in rural or semi-urban areas where cattle intrusion is a concern.

- **Bamboo fencing:** This eco-friendly and traditional method uses vertical bamboo poles tied closely together and supported with horizontal rails. It blends well with the natural surroundings and is particularly suitable for community-driven projects or regions where bamboo is locally available.

- **Chain-link fencing:** It is a durable option for protecting micro-forest plantations. It consists of interwoven galvanized steel wires arranged in a diamond pattern, supported by metal or concrete posts. This type of fencing creates a sturdy physical barrier that effectively prevents entry of animals and unauthorized people while maintaining visibility into the plantation area.

- **Bio-fencing (Living fence):** Bio-fencing involves planting thick, thorny or fast-growing shrub species along the boundary of the plantation. Over time, this natural barrier becomes a protective hedge that supports biodiversity while offering long-term security and visual appeal.

Barbed-wire fencing

Bamboo fencing

Chain-link fencing

Bio-fencing

4.2 Soil testing

Identify the plantation area and divide it into plots if the site is large. Mark sampling spots across the site to get a representative sample of soil for testing.

Soil sample collection:

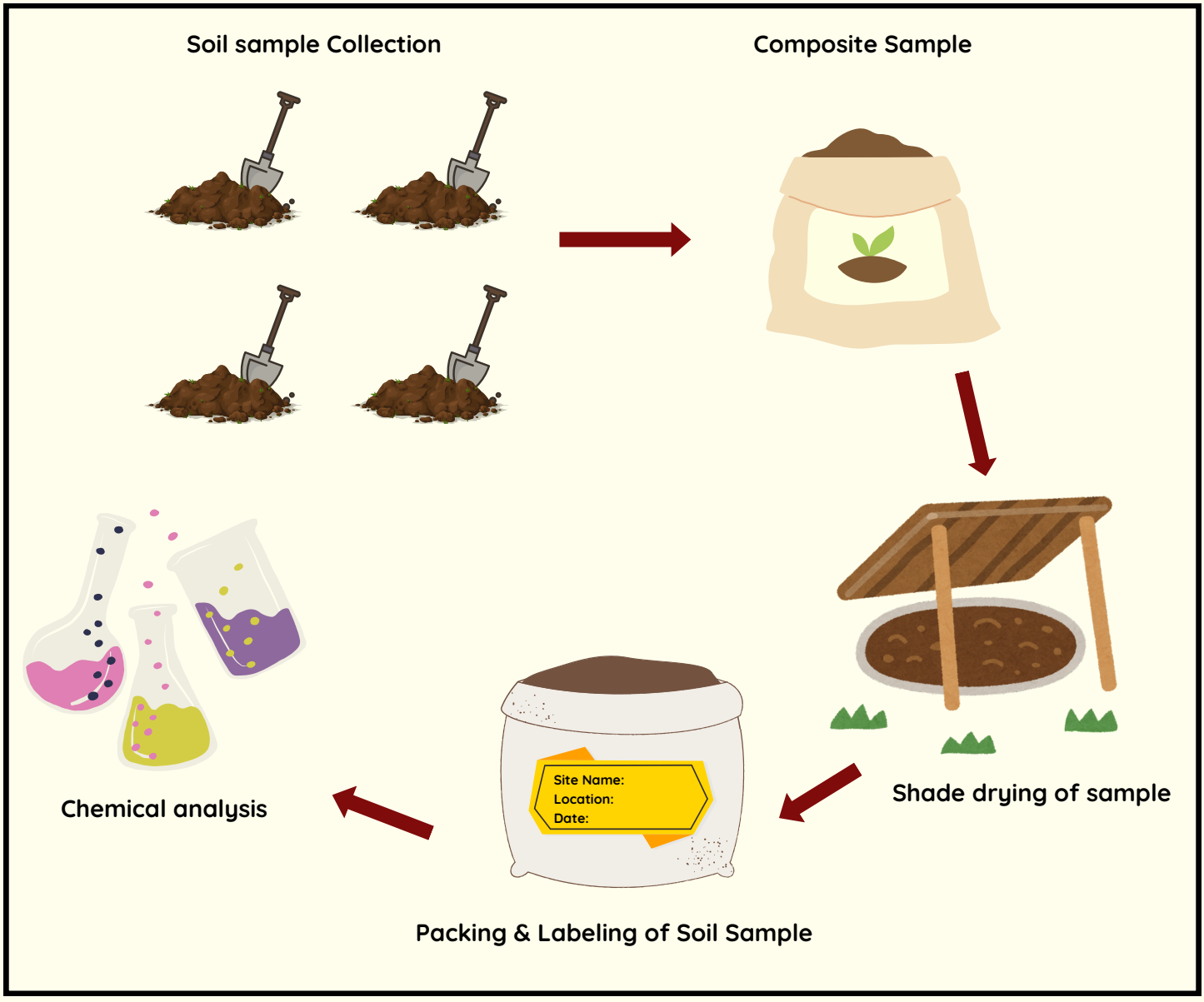
- Collect soil from 4–5 different locations at each plot.
- Take samples from 6 to 8 inches (15–20 cm) depth using a spade or auger.
- Remove stones, roots and debris from the sample.
- Mix all samples in a clean container to form one composite sample.

Drying and packing:

- Air-dry the composite sample in shade (do not dry in direct sunlight).
- Crush and sieve the dried soil using a 2 mm sieve.
- Pack around 500 grams of the sieved soil in a clean cloth or plastic bag.
- Label the bag with site name, location, and date.

Soil testing in laboratory:

- Soil can be tested for Soil texture, pH level, Electrical Conductivity (EC), Organic Carbon (OC), Available Nitrogen (N), Phosphorus (P), and Potassium (K), and Micronutrients (if possible) in the laboratory.



Soil testing procedure

4.3 Finalization of soil amendments

Healthy vegetation cannot grow on degraded grounds because of their low fertility, decreased organic content, weak structure, and restricted water holding capacity. Further, the absence of vegetation accelerates erosion and loss of nutrients. Root growth and microbial activity, which are crucial for soil regeneration, are also impeded by compaction and inadequate drainage. A potential method for restoring such areas is provided by Micro-forest plantations; nevertheless, in order to maintain dense early-stage growth, prior soil treatment is essential. The following soil amendments will thus be used to improve the circumstances for a successful plantation establishment:

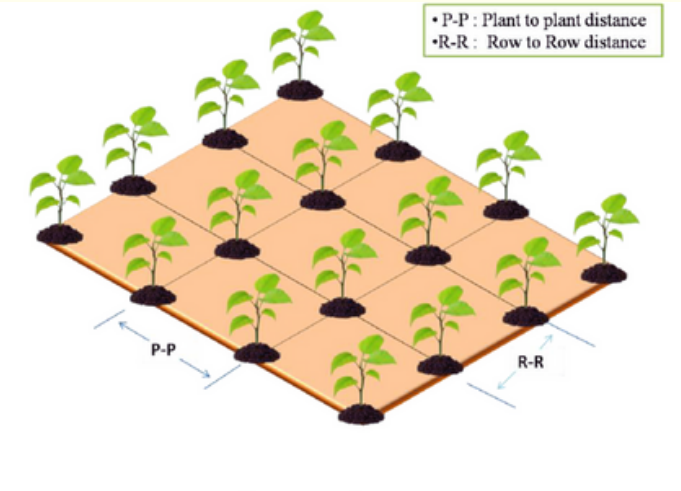
- **Perforators:** Spongy and dry biomass substances like wheat husk, rice husk or groundnut shells are added while bed preparation which improves perforation and help in the rapid development of roots. It can be done by using locally available material in the region where micro-forest needs to be created.
- **Water retainers:** Coco peat, sugarcane bagasse, or similar materials are used as water retainer to improve soil moisture and water retention.
- **Nutrient enhancers:** For nourishment, nutrient enhancers like vermicompost, cow manure, or neo-bio fertilizers are used to enrich the soil.

4.4 Raising of plants in nursery

- **Nursery beds:** The bed size is 1m wide in length so that there is no problem to do inter-cultural operations. Seeds are sown in raised beds with a soil-compost mix. Moisture and shade are maintained for germination.
- **Transplanting in polybags:** Seedlings with 2–3 leaves are shifted to polybags. Soil mix is nutrient-rich to support early growth. The media for polybag should have sand, soil and Farm Yard Manure (FYM) in 1:1:1 ratio to support the early growth and should be kept in shade initially for 2-3 days.
- **Hardening of plants:** In order to acclimatize the plants for the field conditions, they are slowly exposed to sunlight and reduced watering.
- **Plants ready for planting:** Healthy plants, 1–2 feet tall and pencil thickness are selected. These are ready for field planting after 2–3 months.

4.5 Field preparation

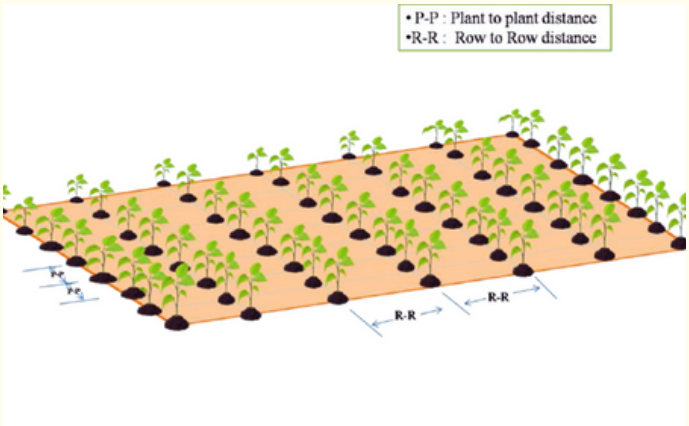
- The plantation site is cleared for weeds, stones and debris. The soil is then loosened up to 0.75 meter deep using manual or mechanical tools.
- Soil amendments like compost, biomass (like dry leaves or rice husk) and microbial cultures are mixed thoroughly into the soil. The area is then levelled or shaped into raised beds if required, to support proper drainage and planting.



Square planting design

4.6 Layout of plantation design

- **Plot size:** It varies from small (100 m²) to larger areas, depending on availability. Design is being prepared either in square pattern or in rectangular pattern as per the site condition. The row to row (R-R) and plant to plant (P-P) spacing varies accordingly.



Rectangular planting design

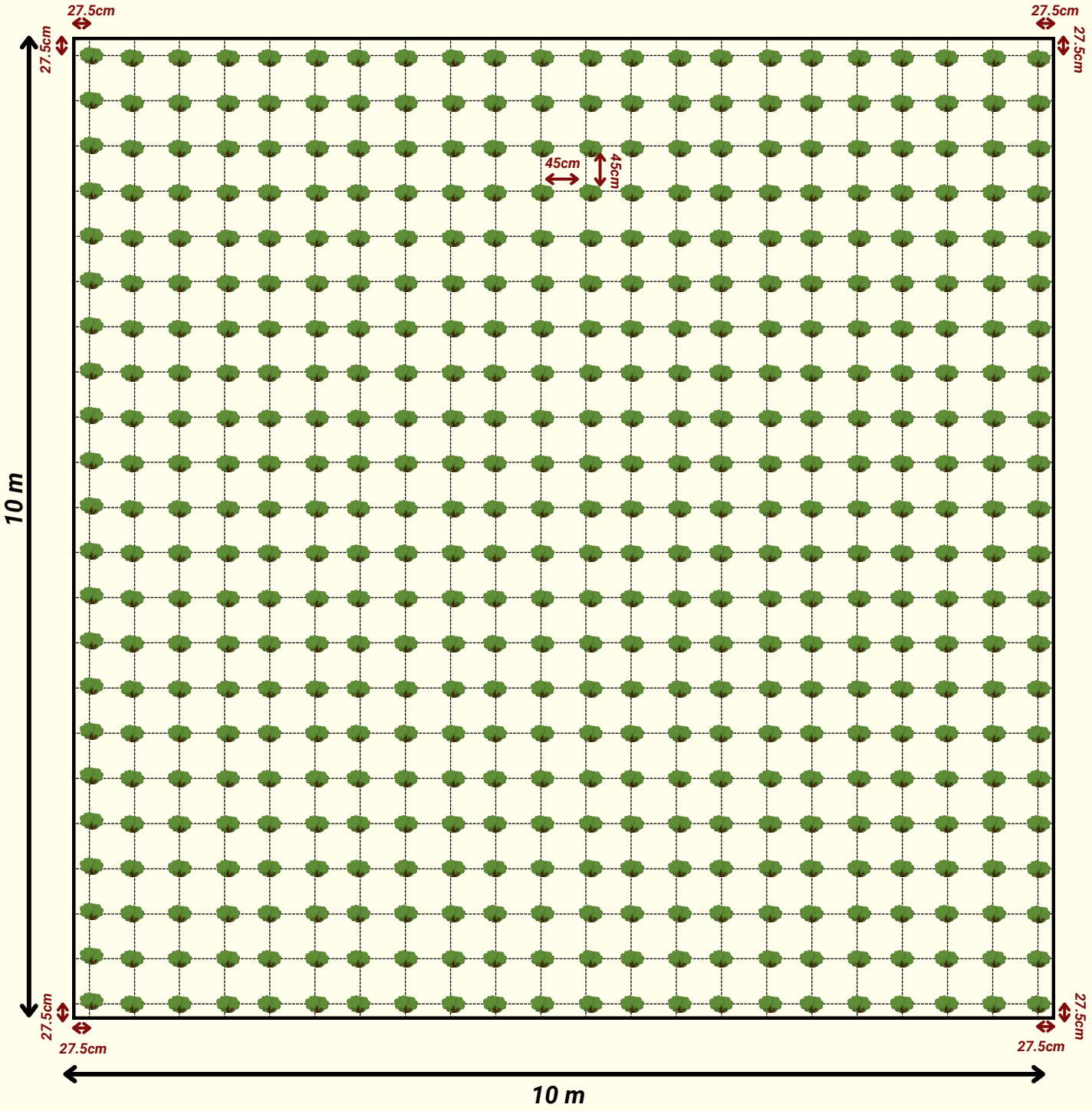
Different planting designs

- **Access paths:** Leave narrow routes for watering and monitoring, depending upon the layout as described in the following sections.

- **Plant spacing:** Design of layout depends upon availability of area and site conditions. While planning layout, spacing must be finalized i.e as close as 45x45 cm to lastly 60x60 cm.

S. No.	Spacing	Number of seedlings per 100 m²	Number of seedlings per acre	Number of seedlings per hectare
1	45cm x 45cm	484	19580	48400
2	50cm x 50cm	400	16180	40000
3	60cm x 60 cm	256	10360	25600

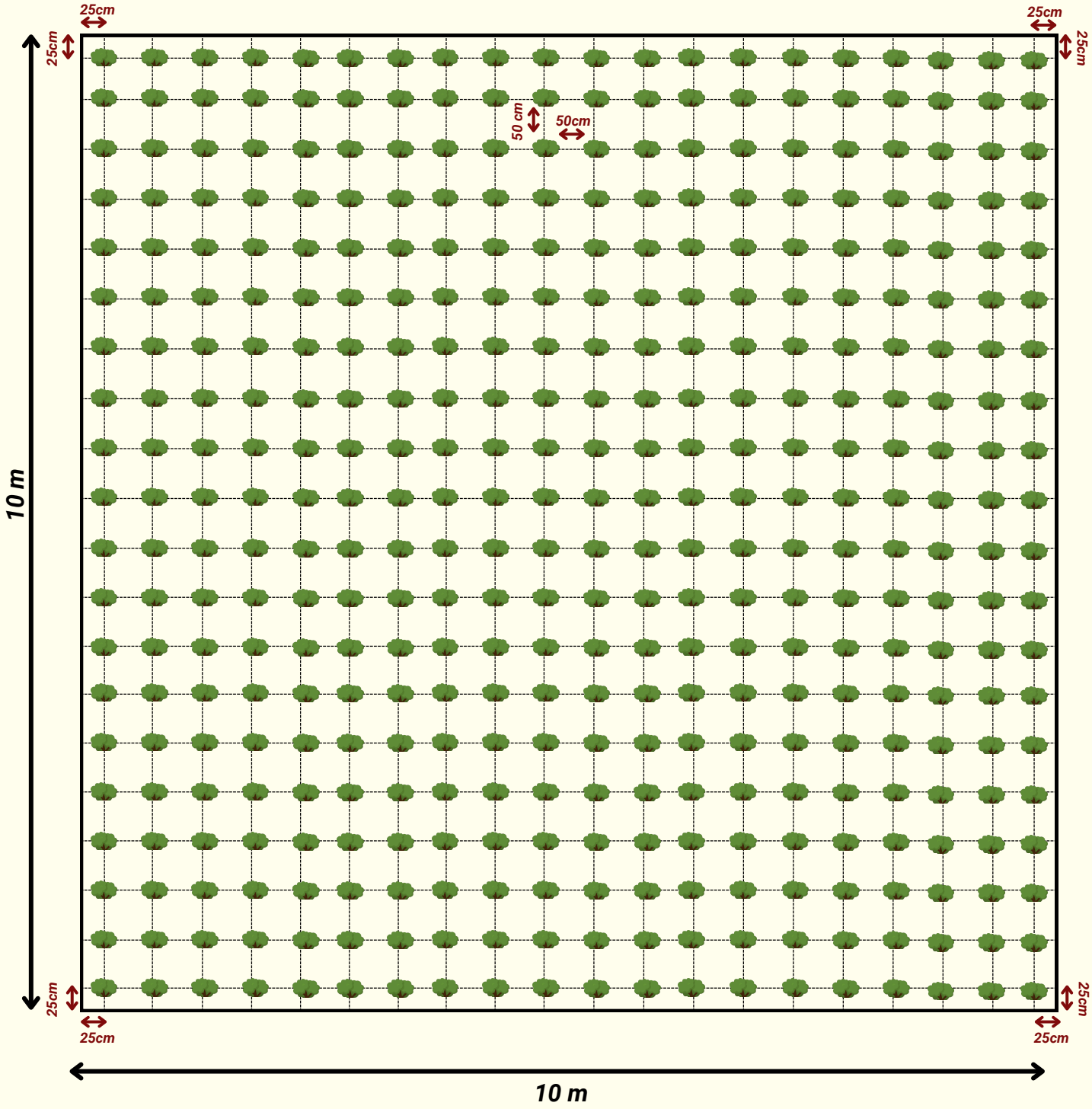
- **Marking the layout:** Use ropes, bamboo stakes, and natural marking materials (e.g., chalk or lime powder) to indicate planting positions. Ensure all planting points are visible and accessible.



Layout design for 100 m² plot with spacing 45 cm x 45 cm

For effective implementation of the Micro-forest in this layout, refer to the key points outlined below:

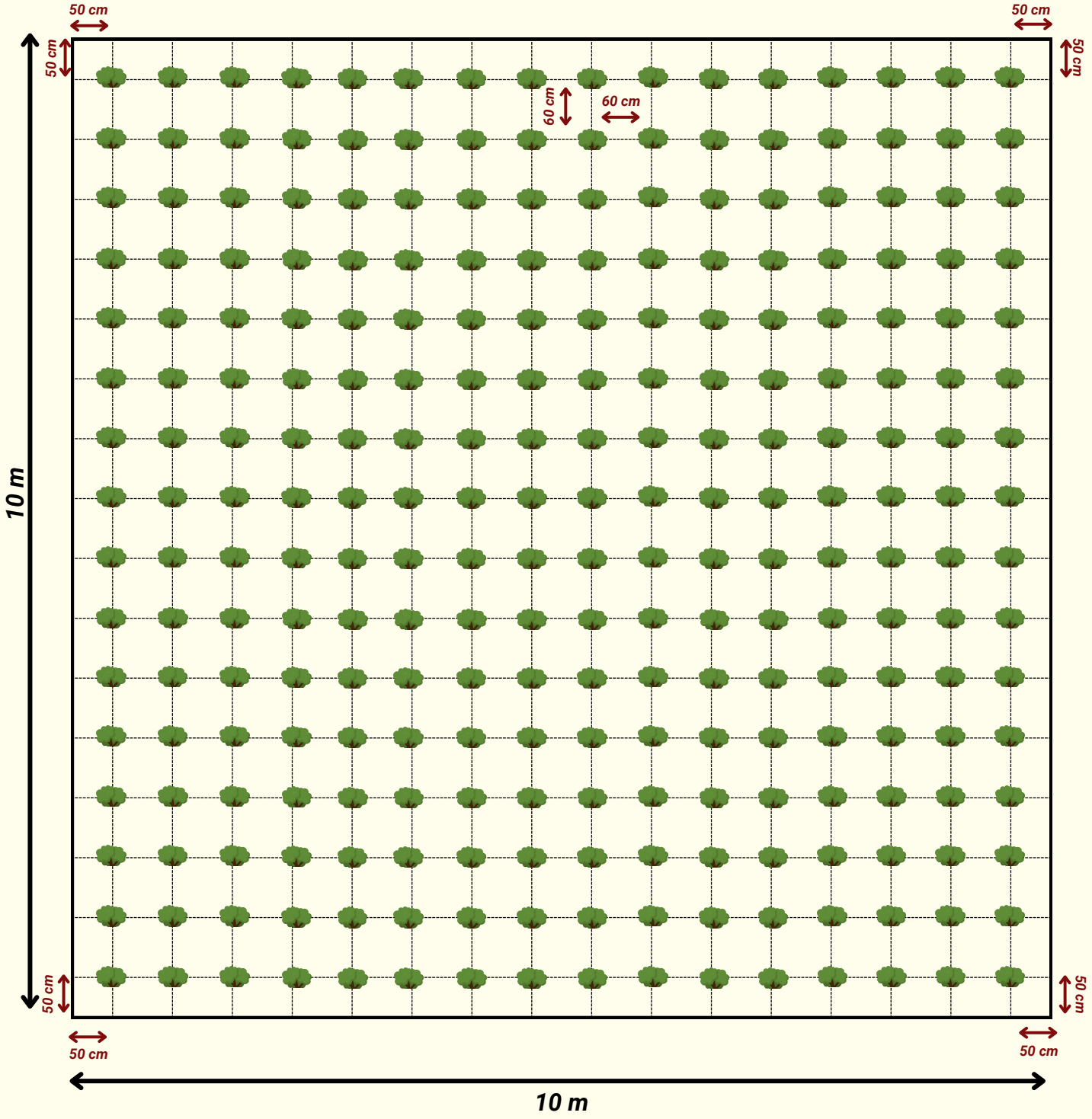
- **Distance to be left from all corners along the plot boundary : 27.5cm**
- **Row to Row Spacing : 45cm x 45cm**
- **Plant to Plant Spacing : 45cm x 45cm**
- **Total No. of Plants in 100 m² : 484**
- **Total No. of Plants in 1 acre : 19,580**
- **Total No. of Plants in 1 hectare : 48,400**



Layout design for 100 m² plot with spacing 50 cm x 50 cm

For effective implementation of the Micro-forest in this layout, refer to the key points outlined below:

- **Distance to be left from all corners along the plot boundary : 25cm**
- **Row to Row Spacing : 50cm x 50cm**
- **Plant to Plant Spacing : 50cm x 50cm**
- **Total No. of Plants in 100 m² : 400**
- **Total No. of Plants in 1 acre : 16,180**
- **Total No. of Plants in 1 hectare : 40,000**



Layout design for 100 m² plot with spacing 60cm x 60 cm

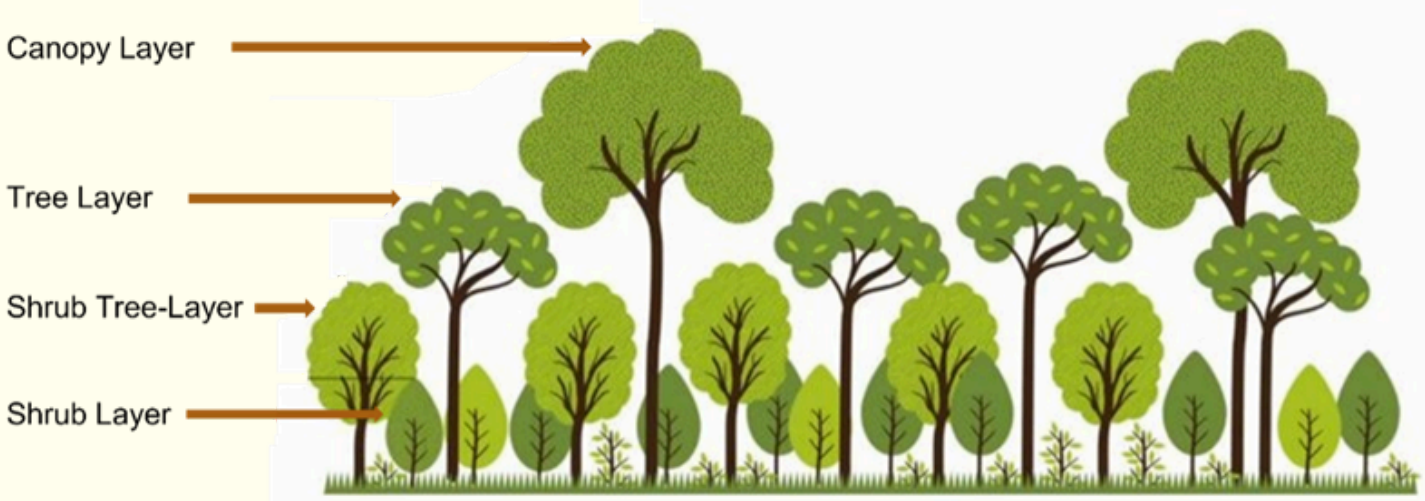
For effective implementation of the Micro-forest in this layout, refer to the key points outlined below:

- **Distance to be left from all corners along the plot boundary : 50cm**
- **Row to Row Spacing : 60cm x 60cm**
- **Plant to Plant Spacing : 60cm x 60cm**
- **Total No. of Plants in 100 m² : 256**
- **Total No. of Plants in 1 acre : 10,360**
- **Total No. of Plants in 1 hectare : 25,600**

Layered structure

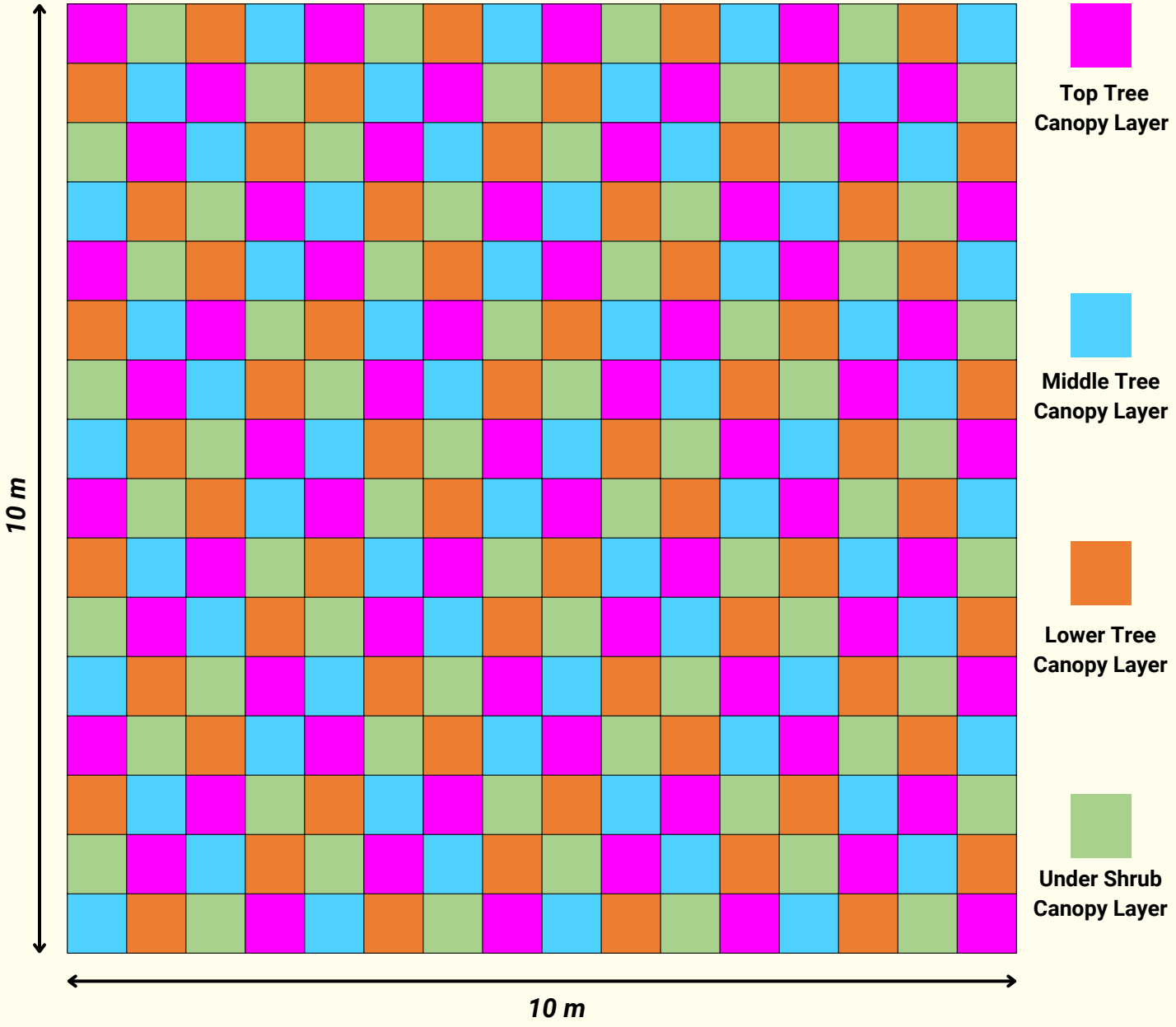
Design the plantation with three main vegetation layers:

- **Upper layer/Canopy layer:** Tall native trees forming the canopy.
- **Middle layer/Tree layer:** Medium-sized species growing in partial sunlight.
- **Lower layer/Shrub tree:** Shrub trees that thrive in shade.
- **Under shrub layer(s):** Shrubs and ground flora that thrive in shade.



High-density multi-layered plantation

Designing a Micro-forest involves creating a compact, multi-layered green zone that reflects the natural structure of a native forest. The goal is to recreate dense vegetation that supports biodiversity, improves microclimate and restores ecological function. To ensure structural diversity within the plantation, a balanced mix of plant layers is recommended, typically comprising 30% tall canopy trees, 50% medium-height species, and 20% lower-layer shrubs and ground flora. With proper design and execution, Micro-forest plantations begin forming self-sustaining forest patches in just 2–3 years. In 10–15 years, these sites mature into dense ecosystems supporting pollinators, birds, small mammals, and improving local environmental quality.

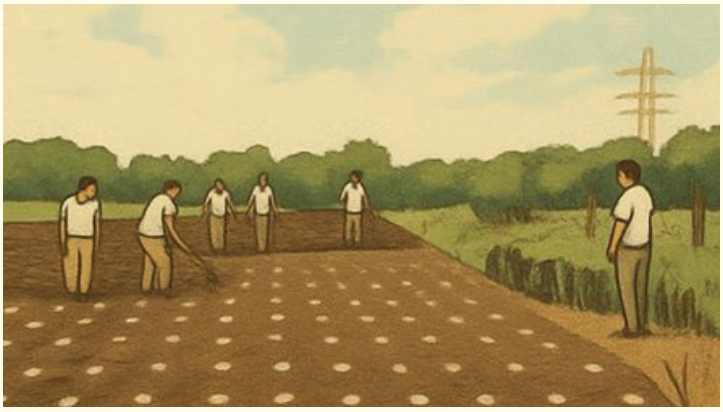


Sample layout of a micro-forest plot (100 m²) depicting four-layered canopy design with 60cm x 60cm spacing

4.7 Plantation

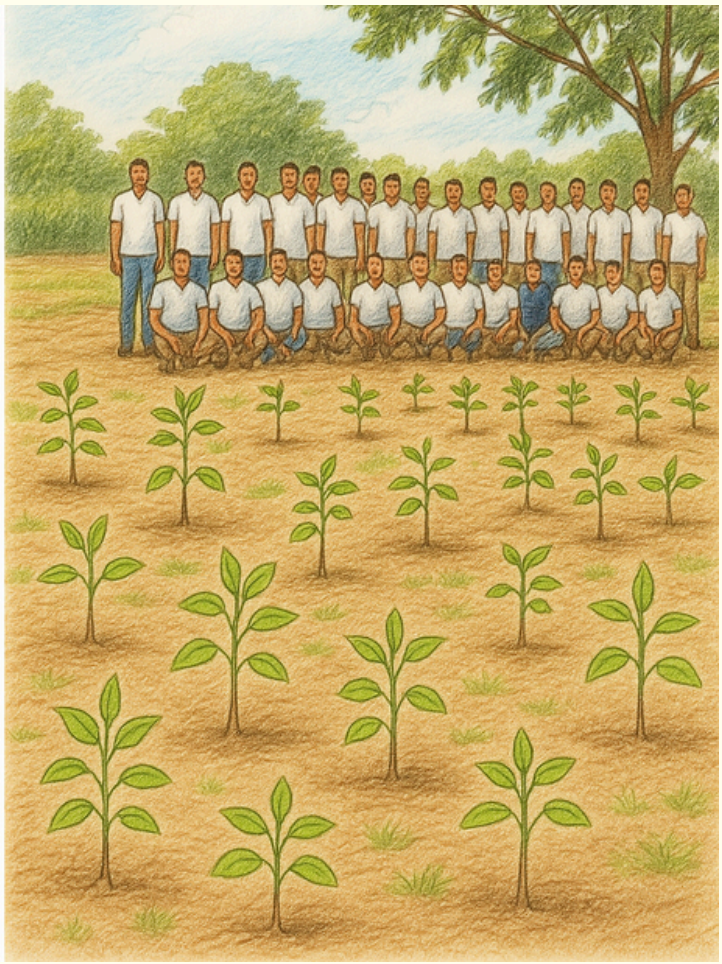
Plantation is a critical phase in establishing a successful micro-forest, translating design into action through careful placement of native species. It begins with precise execution based on the planting plan and ecological principles.

- **Pit preparation:** Begin by digging shallow pits (typically 30–50 cm deep) at the pre-marked positions based on the plantation grid. The spacing is kept tight (generally 3–5 saplings per square meter) to mimic natural forest density and promote vertical growth through healthy competition for sunlight.
- **Planting seedlings:** Gently place the seedlings in the center of each pit, ensuring that the root ball is not disturbed. Cover the roots completely with a mix of enriched topsoil, compost and organic matter to provide immediate nutrients and retain moisture. The soil should be lightly pressed to remove air pockets but not compacted.
- **Support and stabilization:** Use bamboo sticks, wooden stakes or biodegradable ties to support taller or delicate saplings, especially in windy areas. This helps prevent stem breakage and supports upright growth in the early stages.

Site preparation and layout of design

Digging of pits

Plantation of the seedlings

5.1 Irrigation

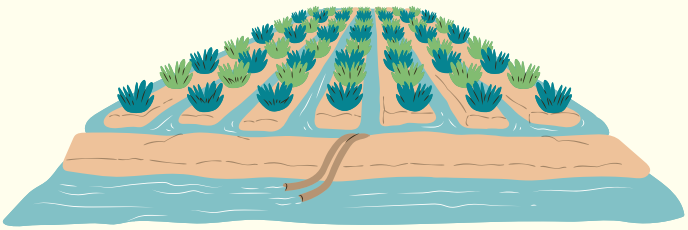
Irrigation is the process of applying water to the crops artificially to fulfil their water requirements. Nutrients may also be provided to the crops through irrigation. The various sources of water for irrigation are wells, ponds, lakes, canals, tube-wells and even dams. In recent years, irrigation through drip and sprinkler methods have grown much popular. Irrigation offers moisture required for growth and development, germination and other related functions. The frequency, rate, amount and time of irrigation are different for different crops and also vary according to the types of soil and seasons.

The different types of irrigation methods used are described as follows:

5.1.1 Surface irrigation (Flood irrigation)

Surface irrigation is the oldest and most common method of irrigation where water is applied and distributed over the soil surface by gravity. It involves no mechanical pumps and is widely used in flat or slightly sloping agricultural fields. This method includes different techniques such as basin, furrow, border strip and flood irrigation. Water flows over the land and infiltrates into the soil to reach the crop roots. The effectiveness of surface irrigation depends on factors like soil type, land slope, water availability and crop type. It is best suited for crops such as rice, sugarcane, wheat and cotton. While it is cost-effective and simple to operate, it can lead to water wastage, soil erosion and uneven water distribution if not managed properly. Proper field leveling, bund construction and water control structures can improve its efficiency. Despite its limitations, surface irrigation remains a practical choice for many farmers, especially in developing regions. It is suitable in areas where abundant water supply is prevalent.

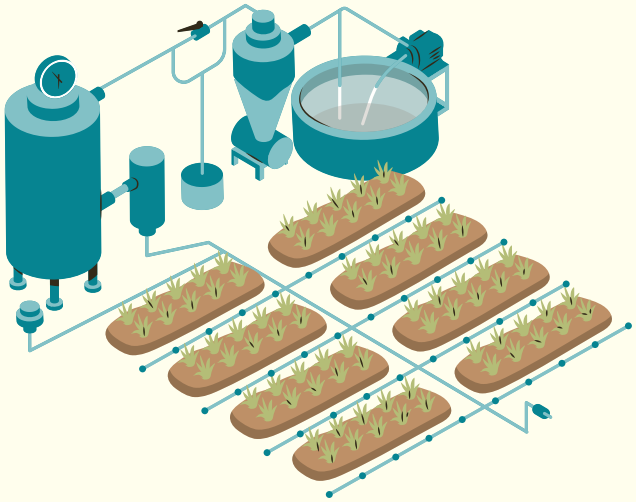
The field is usually leveled and surrounded by small embankments or bunds to retain water. Although flood irrigation is simple, low-cost, and does not require advanced technology, it is highly water-intensive and inefficient. Despite its drawbacks, flood irrigation is still widely used.



Surface irrigation

5.1.2 Drip or Trickle irrigation

Drip or trickle irrigation is an efficient irrigation method of recent origin, which is becoming popular in areas of water scarcity and poor-quality irrigation water. In drip irrigation, water is applied frequently at low rates from a low-pressure delivery system comprising of small diameter plastic pipes fitted with outlets, called emitters or drippers, directly to the land surface close to the plant root zone. Drip irrigation is best suited to water scarcity areas and regions where irrigation water quality is marginal or low (saline water). Among all irrigation methods, drip irrigation is the most efficient and can be practiced for micro-forest plantation.



Drip irrigation system layout

The comparative irrigation efficiencies under different methods of irrigation is given in the following Table below:

Irrigation efficiencies under different methods of irrigation (%)

Irrigation efficiencies	Methods of irrigation		
	Surface Irrigation	Sprinkler Irrigation	Drip Irrigation
Conveyance efficiency (%)	40-50(canal) 60-70(well)	100	100
Application efficiency (%)	60-70	70-80	90-95
Surface water moisture evaporation (%)	30-40	30-40	20-25
Overall efficiency (%)	30-35	50-60	90-95

Source: Sivanappan, 1998

5.1.3 Sprinkler irrigation

Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The sprinkler system irrigates the field and thus it is widely used in sandy areas as it checks the wastage of water through seepage and evaporation. The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water.

Sprinkler irrigation

5.2 Weed management

Manual weeding is the process of removing unwanted plants (weeds) from crop fields by hand or using simple tools like a hoe or khurpi. It is a traditional, low-cost method commonly practiced in small-scale farming. Manual weeding helps reduce competition for nutrients, water, sunlight and space, allowing the main crop to grow better and yield more. Regular manual weeding also helps in monitoring crop health and soil condition. It is environmentally friendly and does not harm the soil or beneficial organisms.

5.3 Mulching

Organic mulch is a natural material spread over the soil surface to conserve moisture, improve fertility, and reduce weed growth. Use of organic mulch to retain soil moisture and regulate temperature is also important in micro-forest. Common types of organic mulch include straw, leaves, grass clippings, compost, and bark. As it decomposes, organic mulch enriches the soil with nutrients and improves soil structure, making it more fertile and easier to work.

It helps regulate soil temperature, protects roots from extreme weather, and reduces erosion. Organic mulch also supports beneficial soil organisms like earthworms and microbes. Unlike synthetic mulches, it is environmentally friendly and sustainable. Regular replenishment is needed as it breaks down over time, benefiting long-term soil health.

Organic mulch has the following advantages:

- It helps keep the soil moist by reducing water loss due to sunlight and wind.
- It controls soil temperature by keeping the soil cooler in summer and warmer in winter.
- It also improves soil health as it slowly breaks down and adds nutrients to the soil.

5.4 Pest and disease management

Timely monitoring and use of biological agents to prevent damage to the crops is very important to keep the plantation healthy. Use of right kind of bio-agent treatment and recommended dosages is useful in pest management programmes.

Microbial bio-pesticides: These are naturally occurring microorganisms (fungi, bacteria, or viruses) that infect or kill pests. Some of the examples are:

- *Bacillus thuringiensis* (Bt): A bacteria that produces toxins harmful to lepidopteran caterpillars.
- *Beauveria bassiana:* A fungus that infects insects like beetles and whiteflies and lepidopteran.
- Nucleopolyhedrovirus (NPV): A virus most effective against lepidopteran insect pests.

Botanical extracts and natural oils: These are plant-based products that deter or kill pests. Some examples are:

- **Neem oil:** Effective against a wide range of pests and has antifungal properties.
- **Neem cake:** Protects from pests like nematodes and termites.
- **Garlic-chili extract:** Acts as a repellent for insects.
- **Soap sprays or horticultural oils:** Help control mites and soft-bodied insects by smothering them.

For the control of diseases especially soil borne diseases in nursery and micro-forest plantation, *Trichoderma* species can be extensively used. For the control of Powdery Mildew, *Ampelomyces quisqualis* can also be used.

5.5 Fertilizer management

Fertilizers are chemical or natural substances added to soil or plants to enhance their growth and productivity. They provide essential nutrients like nitrogen (N), phosphorus (P), and potassium (K), which are vital for plant development. Organic fertilizers (compost, manure) help improve crop yield, boost soil fertility, and support healthy plant growth.

However, excessive use of fertilizers can lead to soil degradation, water pollution, and harm to beneficial organisms. Proper selection and balanced application are crucial for sustainable plantation. Modern plantation systems rely on fertilizers to meet food demand and maintain soil nutrient balance. Integrated nutrient management practices are being encouraged to optimize fertilizer use.

5.6 Mortality replacement

Mortality replacement involves replanting new saplings to substitute those that have died due to various factors such as pest and disease attacks, root damage, transplanting shock, water scarcity, or harsh environmental conditions. Other common causes include poor soil quality, inadequate sunlight, improper planting techniques, and competition from weeds. This practice is essential to maintain a uniform plant population, support healthy growth, and ensure optimal yield from the plantation.

Chapter 6: Budget

A micro-forest plantation is a dense, multilayered plantation model designed to replicate a natural forest ecosystem in a small area. It promotes biodiversity, improves soil health, and contributes to carbon sequestration. The implementation requires a carefully structured work plan spread over four years and cost estimates that vary depending on factors such as plant spacing, fencing type, and water availability.

The cost norms of micro-forest plantations can vary significantly depending on key factors such as plant spacing, type of fencing, and availability of water. Spacing affects the number of saplings required per hectare—closer spacing increases plant density and upfront costs for saplings, labour, and inputs, while wider spacing reduces these.

Fencing, crucial for protection from grazing and encroachments, is another major cost driver. Barbed wire fencing is common and relatively affordable, but in areas with higher threat levels, bamboo or chain-link fencing may be needed, affecting installation and maintenance expenses.

Water availability plays a critical role in both capital and recurring costs. In rain-fed areas with reliable monsoon, irrigation needs are minimal. However, in arid or semi-arid regions, drip or manual irrigation systems may be essential, raising infrastructure and operational costs significantly.

As per the principle of Micro-forest, 2-5 seedlings have to be planted per meter square, hence three spacings are being recommended as follows:

S. No.	Spacing	Number of seedlings per 100 m²	Number of seedlings per acre	Number of seedlings per hectare
1	45cm x 45cm	484	19580	48400
2	50cm x 50cm	400	16180	40000
3	60cm x 60 cm	256	10360	25600

On the basis of spacing, 3 models for cost norms per hectare along with work plan for 4 years without fencing have been formulated.

6.1 Model–1: Cost Norms per Hectare with Action Plan (4 Years) for 45cm x 45 cm Spacing with Pipeline/Drip Irrigation from Borewell without Fencing

Area = 1 hectare

Spacing = 45cm x 45cm

Seedlings per hectare = 48400

Daily Wages Rate = ₹ 470/- (rate will be modified as per the labour rate prevailing in a particular state)

S. No.	Work Description	Unit	Quantity/Labour	Rate per unit (in ₹)	Amount (in ₹)
	Zero Year Work Plan (Pre-plantation Activities)				
1	Site inspection, demarcation and layout	MD	2	470/-	940.00
2	Site cleaning (Clearing of bushes and grasses)	MD	10	470/-	4700.00
3	Soil Testing	LS			3000.00
4	Excavation of site up to 60-75cm (through excavator or labour) – 1 MD for 30 square meter area up to recommended depth	MD	333	470/-	156510.00
5	Cost of different soil amendments with transportation (perforators, bio-fertilizers etc.) – Farmyard Manure- 28 tons @ Rs 2/-kg Coco peat – 500 kg @ Rs 20/-kg Neem cake – 500 kg @ Rs 160/- kg	LS			146000.00
6	Breaking down the lumps and spreading and mixing of amendments evenly in the site (including transportation up to 100 meters (40 m2 per one man day)	MD	250	470/-	117500.00
7	Installation of Irrigation facilities i.e. boring tube well with storage tanks and electricity panels and or solar system with a small pump house	LS			600000.00
				Total	1028650.00
				Contingency (3%)	30859.50
				Grand Total	1059509.50 Or say **1059510.00**

S. No.	Work Description	Unit	Quantity/Labour	Rate per unit (in ₹)	Amount (in ₹)
	1st Year Work Plan				
1	Alignment and staking including laying base line – 0.002 MD per pit	MD	97	470/-	45590.00
2	Pit Digging (30cm x 30cm x 30cm) – 0.01 MD per pit	MD	484	470/-	227480.00
3	Purchasing of seedlings (28160 seedlings including 10% mortality replacement)	Nos.	53240	25/-	1331000.00
4	Transportation of seedlings from nursery to the site along with loading and unloading and its care in the site	Nos.	53240	2.5/-	133100.00
5	Internal Transportation of seedlings – 0.004 MD per seedling	MD	97	470/-	45590.00
6	Planting of seedlings - 0.01 MD per seedling	MD.	484	470/-	227480.00
7	Preparing support sticks from tall saplings or tree branches or bamboo	Nos.	48400	5/-	242000.00
8	Providing support and tying with twine – 1000 sticks per man day (0.001 MD)	MD	48	470/-	22560.00
9	Weeding 2 times	MD	38	470/-	17860.00
10	Maintenance and Watch and Ward – 1 man day per month for 9 months	MD	270	470/-	126900.00
11	Inspection and Repair of Irrigation System	LS			5000.00
12	Electricity/diesel charges @ 10000 per month	Month	9	10000/-	90000.00
				Total	2514560.00
				Contingency @ 3%	75436.80
				Price Escalation @ 5%	125728.00
				Grand Total	2715724.80 Or say **2715725.00**

S. No.	Work Description	Unit	Quantity/Labour	Rate per unit (in ₹)	Amount (in ₹)
	2nd Year Work Plan				
1	Internal Transportation of seedlings – 0.004 MD per seedling	MD	10	470/-	4700.00
2	Mortality replacement (2560 seedlings) – 0.01 MD per seedling	MD	48	470/-	22560.00
3	Maintenance and Watch and Ward – 1 man day per month for 12 months	MD	365	470/-	171550.00
4	Inspection and Repair of Irrigation System	LS			10000.00
5	Electricity/diesel charges @ 10000 per month	Month	12	10000	120000.00
				Total	328810.00
				Contingency @ 3%	9864.30
				Price Escalation @ 10%	32881.00
				Grand Total	371555.30 Or say **371555.00**

S. No.	Work Description	Unit	Quantity/Labour	Rate per unit (in ₹)	Amount (in ₹)
	3rd Year Work Plan				
1	Maintenance and Watch and Ward – 1 man day per month for 12 months	MD	365	470/-	171550.00
2	Inspection and Repair of Irrigation System	LS			10000.00
3	Electricity/diesel charges @ 10000 per month	Month	12	10000/-	120000.00
				Total	301550.00
				Contingency @ 3%	9046.50
				Price Escalation @ 15%	45232.50
				Grand Total	**355829.00**

Model–2: Cost Norms per Hectare with Action Plan (4 Years) for 50cm x 50cm Spacing with Pipeline/Drip Irrigation from Borewell without Fencing

Area = 1 hectare

Spacing = 50cm x 50cm

Seedlings per hectare = 40000

Daily Wages Rate = ₹ 470/- (rate will be modified as per the labour rate prevailing in a particular state)

S. No.	Work Description	Unit	Quantity/Labour	Rate per unit (in ₹)	Amount (in ₹)
	Zero Year Work Plan (Pre-plantation Activities)				
1	Site inspection, demarcation and layout	MD	2	470/-	940.00
2	Site cleaning (Clearing of bushes and grasses)	MD	10	470/-	4700.00
3	Soil Testing	LS			3000.00
4	Excavation of site up to 60-75cm (through excavator or labour) – 1 MD for 30 square meter area up to recommended depth	MD	333	470/-	156510.00
5	Cost of different soil amendments with transportation (perforators, bio-fertilizers etc.) – Farmyard Manure- 28 tons @ Rs 2/-kg Coco peat – 500 kg @ Rs 20/-kg Neem cake – 500 kg @ Rs 160/- kg	LS			146000.00
6	Breaking down the lumps and spreading and mixing of amendments evenly in the site (including transportation up to 100 meters (40 m2 per one man day)	MD	250	470/-	117500.00
7	Installation of Irrigation facilities i.e. boring tube well with storage tanks and electricity panels and or solar system with a small pump house	LS	LS		600000.00
				Total	1028650.00
				Contingency (3%)	30859.50
				Grand Total	1059509.50 Or say **1059510.00**

S. No.	Work Description	Unit	Quantity/Labour	Rate per unit (in ₹)	Amount (in ₹)
	1st Year Work Plan				
1	Alignment and staking including laying base line – 0.002 MD per pit	MD	80	470/-	37600.00
2	Pit Digging (30cm x 30cm x 30cm) – 0.01 MD per pit	MD	400	470/-	188000.00
3	Purchasing of seedlings (28160 seedlings including 10% mortality replacement)	Nos.	44000	25/-	1100000.00
4	Transportation of seedlings from nursery to the site along with loading and unloading and its care in the site	Nos.	44000	2.5/-	110000.00
5	Internal Transportation of seedlings – 0.004 MD per seedling	MD	80	470/-	37600.00
6	Planting of seedlings - 0.01 MD per seedling	MD.	400	470/-	188000.00
7	Preparing support sticks from tall saplings or tree branches or bamboo	Nos.	40000	5/-	200000.00
8	Providing support and tying with twine – 1000 sticks per man day (0.001 MD)	MD	40	470/-	18800.00
9	Weeding 2 times	MD	31	470/-	14570.00
10	Maintenance and Watch and Ward – 1 man day per month for 9 months	MD	270	470/-	126900.00
11	Inspection and Repair of Irrigation System	LS			5000.00
12	Electricity/diesel charges @ 10000 per month	Month	9	10000/-	90000.00
				Total	2116470.00
				Contingency @ 3%	63494.10
				Price Escalation @ 5%	105823.50
				Grand Total	2285787.60 Or say **2285788.00**

S. No.	Work Description	Unit	Quantity/Labour	Rate per unit (in ₹)	Amount (in ₹)
	2nd Year Work Plan				
1	Internal Transportation of seedlings – 0.004 MD per seedling	MD	8	470/-	3760.00
2	Mortality replacement (2560 seedlings) – 0.01 MD per seedling	MD	40	470/-	18800.00
3	Maintenance and Watch and Ward – 1 man day per month for 12 months	MD	365	470/-	171550.00
4	Inspection and Repair of Irrigation System	LS			10000.00
5	Electricity/diesel charges @ 10000 per month	Month	12	10000/-	120000.00
				Total	324110.00
				Contingency @ 3%	9723.30
				Price Escalation @ 10%	32411.00
				Grand Total	366244.30 Or say **366244.00**

S. No.	Work Description	Unit	Quantity/Labour	Rate per unit (in ₹)	Amount (in ₹)
	3rd Year Work Plan				
1	Maintenance and Watch and Ward – 1 man day per month for 12 months	MD	365	470/-	171550.00
2	Inspection and Repair of Irrigation System	LS			10000.00
3	Electricity/diesel charges @ 10000 per month	Month	12	10000/-	120000.00
				Total	301550.00
				Contingency @ 3%	9046.50
				Price escalation @ 15%	45232.50
				Grand Total	**355829.00**

Model–3: Cost Norms per Hectare with Action Plan (4 Years) for 60cm x 60cm Spacing with Pipeline/Drip Irrigation from Borewell without Fencing

Area = 1 hectare

Spacing = 60cm x 60cm

Seedlings per hectare = 25600

Daily Wages Rate = ₹ 470/- (rate will be modified as per the labour rate prevailing in a particular state)

S. No.	Work Description	Unit	Quantity/Labour	Rate per unit (in ₹)	Amount (in ₹)
	Zero Year Work Plan (Pre-plantation Activities)				
1	Site inspection, demarcation and layout	MD	2	470/-	940.00
2	Site cleaning (Clearing of bushes and grasses)	MD	10	470/-	4700.00
3	Soil Testing	LS			3000.00
4	Excavation of site up to 60-75cm (through excavator or labour) – 1 MD for 30 square meter area up to recommended depth	MD	333	470/-	156510.00
5	Cost of different soil amendments with transportation (perforators, bio-fertilizers etc.) – Farmyard Manure- 28 tons @ Rs 2/-kg Coco peat – 500 kg @ Rs 20/-kg Neem cake – 500 kg @ Rs 160/- kg	LS			146000.00
6	Breaking down the lumps and spreading and mixing of amendments evenly in the site (including transportation up to 100 meters (40 m2 per one man day)	MD	250	470/-	117500.00
7	Installation of Irrigation facilities i.e. boring tube well with storage tanks and electricity panels and or solar system with a small pump house	LS			600000.00
				Total	1028650.00
				Contingency (3%)	30859.50
				Grand Total	1059509.50 Or say **1059510.00**

S. No.	Work Description	Unit	Quantity/Labour	Rate per unit (in ₹)	Amount (in ₹)
	1st Year Work Plan				
1	Alignment and staking including laying base line – 0.002 MD per pit	MD	51	470/-	23970.00
2	Pit Digging (30cm x 30cm x 30cm) – 0.01 MD per pit	MD	256	470/-	120320.00
3	Purchasing of seedlings (28160 seedlings including 10% mortality replacement)	Nos.	28160	25/-	704000.00
4	Transportation of seedlings from nursery to the site along with loading and unloading and its care in the site	Nos.	28160	2.5/-	70400.00
5	Internal Transportation of seedlings – 0.004 MD per seedling	MD	51	470/-	23970.00
6	Planting of seedlings - 0.01 MD per seedling	MD.	256	470/-	120320.00
7	Preparing support sticks from tall saplings or tree branches or bamboo	Nos.	25600	5/-	128000.00
8	Providing support and tying with twine – 1000 sticks per man day (0.001 MD)	MD	26	470/-	12220.00
9	Weeding 2 times	MD	20	470/-	9400.00
10	Maintenance and Watch and Ward – 1 man day per month for 9 months	MD	270	470/-	126900.00
11	Inspection and Repair of Irrigation System	LS			5000.00
12	Electricity/diesel charges @ 10000 per month	Month	9	10000/-	90000.00
				Total	1434500.00
				Contingency @ 3%	43035.00
				Price Escalation @ 5%	71725.00
				Grand Total	**1549260.00**

S. No.	Work Description	Unit	Quantity/Labour	Rate per unit (in ₹)	Amount (in ₹)
	2nd Year Work Plan				
1	Internal Transportation of seedlings – 0.004 MD per seedling	MD	5	470/-	2350.00
2	Mortality replacement (2560 seedlings) – 0.01 MD per seedling	MD	26	470/-	12220.00
3	Maintenance and Watch and Ward – 1 man day per month for 12 months	MD	365	470/-	171550.00
4	Inspection and Repair of Irrigation System	LS			10000.00
5	Electricity/diesel charges @ 10000 per month	Month	12	10000/-	120000.00
				Total	316120.00
				Contingency @ 3%	9483.60
				Price Escalation @ 10%	31612.00
				Grand Total	357215.60 Or say **357216.00**

S. No.	Work Description	Unit	Quantity/Labour	Rate per unit (in ₹)	Amount (in ₹)
	3rd Year Work Plan				
1	Maintenance and Watch and Ward – 1 man day per month for 12 months	MD	365	470/-	171550.00
2	Inspection and Repair of Irrigation System	LS			10000.00
3	Electricity/diesel charges @ ₹ 10000 per month	Month	12	10000/-	120000.00
				Total	301550.00
				Contingency @ 3%	9046.50
				Price escalation @ 15%	45232.50
				Grand Total	**355829.00**

Abstract of Estimates
(for 1 hectare without fencing)

S. No.	Year of Execution	Cost estimates for different spacings (in ₹)		
		45cm x 45cm	**50cm x 50cm**	**60cm x 60cm**
1	Zero year	1059510.00	1059510.00	1059510.00
2	1st Year	2715725.00	2285788.00	1549260.00
3	2nd Year	371555.00	366244.00	357216.00
4	3rd Year	355829.00	355829.00	355829.00
	Total	**4502619.00**	**4067371.00**	**3321815.00**
	Third Part Monitoring by R&D Organization working in Forestry Sector @ 5%	**225130.95**	**203368.55**	**166090.75**
	Grand Total	4727749.95 or say **4727750.00**	4270739.55 or say **4270740.00**	3487905.75 or say **3487906.00**

***This data on pro rata basis may be used to calculate the cost-estimates for 100 m², 1 acre and/or any other area measurement.**

***If biotic pressure is there at any site, fencing may be undertaken as per the cost norms of the concerned state.**

References

- Asia, I. S. (2022). Guidelines for development of Miyawaki forests in India. ICLEI South Asia.
- Butfoy, L. (2023). Miyawaki Method Handbook. Kent County Council. (Part of the Trees Outside Woodlands Programme).
- Creating Tomorrow's Forests. (2022). The Miyawaki method for creating forests: Restoring biodiversity by creating habitats and planting trees.
- Forest Survey of India. (2023). India State of Forest Report 2023 (Volume 1), Forest Survey of India, Ministry of Environment, Forest & Climate Change, Government of India.
- ICAR. (2003). Report of the Quinquinnial Review Team on ICAR. All India Research Project on Application of Plastic in agriculture, Vol. II.
- ICFRE - Tropical Forest Research Institute. (2023). A manual on Miyawaki plantation (TFRI/Tech. Bulletin/04/2023/41). Indian Council of Forestry Research and Education, Dehradun.
- Kulkarni, S.A. (1998). Status and scope of sprinkler irrigation in Maharashtra. Workshop on Micro-irrigation and Sprinkler Irrigation Systems, Central Board of Irrigation and Power (CBI&P), New Delhi.
- Kumar, S. and Mohammed, N. (2023). Standard Operating Procedures for Post Plantation Techniques, ICFRE- Institute of Forest Productivity (IFP), Ranchi.
- Lewis, H. (2022). Mini-forest revolution: Using the Miyawaki method to rapidly rewild the world. Chelsea Green Publishing.
- Mane M.S, Ayare, B.L. and Magar, S.S. (2008). Principles of Drip Irrigation System. Pub Jain Brothers, New Delhi.
- Michael, A.M. (1993). Irrigation Theory and Practice. Vikas Publishing House Pvt. Ltd., New Delhi.
- Miyawaki, A. (1999) Creative ecology: restoration of native forests by native trees. Plant Biotechnol 16(1):15–25.
- Schirone, B., Salis, A. and Vessella, F. (2011). Effectiveness of the Miyawaki method in Mediterranean forest restoration programs. Landscape and Ecological Engineering, 7, 81-92.
- Sivanappan, R. K. (1998). Status, scope and future prospects of micro irrigation in India.Proc. Workshop on micro irrigation and sprinkler irrigation system. CBIP New Delhi, April 28-30, 1998: 1-7.
- Spicetree Wellness Resorts. (n.d.). A complete guide to the Miyawaki method.

Annexure

List of suggested tree/shrubs/herbs species according to different canopy layers existed in the top three forest types (based on area) in different states of India

Source: Champion & Seth (1968); FSI (2019)

S. No.	State & Union territories	Forest types	Forest cover (%)*
1	Andhra Pradesh	**5A/C3 Southern Dry Mixed Deciduous**	42.97
		Forest Chirodi R. F., Andhra Pradesh	
		Top Storey: *Terminalia tomentosa, Bauhinia racemosa, Acacia arabica, A. catechu, Boswellia serrata, Buchanania, lanzan, Azadirachta indica, Ougeinia oojeinensis, Flacourtia indica*	
		Middle Storey: *Gymnosporia spinosa, Ziziphus mauritiana, Z. xylopyrus, Morinda tinctoria*	
		Lower storey: *Mimosa hamata, Terminalia tomentosa, Grewia hirsuta*	
		Cuddalore Nallamalais, S. Kurnool Division, A.P.	
		Top Storey/ Middle Storey: *Anogeissus latifolia, Cleistanthus collinus, Terminalia tomentosa, Pterocarpus marsupium, P. santalinus, Hardwickia binata, Tectona grandis*	
		Middle Storey: *Dendrocalamus strictus*	
		S. Cuddapah Division, A. P	
		Top Storey/ Middle Storey: *Terminalia pallida, Shorea talura, S. tumbuggaia, Eugenia alternifolia, Mangifera indica, Albizia odoratissima*	
		Lower storey: *Phoenix acaulis*	
		5B/DS1 Dry Deciduous Scrub	31.58
		Mansurabad, Andhra Pradesh	
		Acacia leucophloea, Bauhinia racemosa, Dalbergia paniculata, Wrightia tinctoria, Ziziphus xylopyrus, Cassia fistula, Randia, Annona spp.	
		3B/C2 Southern Moist Mixed Deciduous Forest	5.20
		Top Storey: *Pterocarpus marsupium, Salmalia malabarica, Terminalia bellirica, Anogeissus latifolia, Dalbergia latifolia, Terminalia tomentosa, Lannea coromandelica, Madhuca indica, Garuga pinnata*	

		Middle Storey: *Miliusa tomentosa, Polyalthia cerasoides, Lagerstroemia parviflora, Emblica officinalis, Xylia xylocarpa, Grewia tiliifolia, Schrebera swietenioides, Cleistanthus collinus, Diospyros montana, Flacourtia indica, Dendrocalamus strictus*	
		Lower Storey: *Ziziphus oenopolia, Casearia graveolens, Helictere sisora, Desmodium gangeticum, Terminalia tomentosa predominating accompanied by Pterocarpus, Adina, Salmalia, Grewia*	
2	**Arunachal Pradesh**	**8B/C1 East Himalayan Sub-Tropical Wet Hill Forest**	**24.35**
		Top storey: *Lithocarpuselegans, Quercus fenestrata, Quercus lamellosa, Quercus griffithii, Castanopsis sp., Schima, Cinnamomum, Saurauia spp., Litsea spp., Machilus, Syzygium, Cedrela toona, Phoebe lanceolata, Beilschmiedia, Cinnamomum cecicodaphne, Schima, Lauraceae (many spp.). Litsea sp., Magnolia sp., Alnus sp., Betula sp., Cinnamomum, Pinus wallichiana*	
		Middle/ Lower storey: *Elaeagnus sp., Berberis wallichiana, Maesa indica, Strobilanthes sp., Zanthoxylum sp., Gaultheria sp., Rhododendron sp.,Psychotria, Flacourtia, Symplocos, Crateva nurvala, Emblica*	
		Middle Storey: *Quercus sp., Lithocarpus, Schima, Castanopsis spp., Betula alnoides, Acer oblongum, Engelhardia, Symplocos* **Lower storey:** *Pittosporum sp., Myrsine, Debregeasia, Rubus*	
		11B/C1 East Himalayan Wet Temperate Forest	**22.92**
		Top Storey: *Magnolia, Manglietia, Michelia, Quercus, Acer, Prunus, Pyrus, Symingtonia (Bucklandia) populnea, Alnus nepalensis, Betula alnoides, Carpinus viminea , Alnus nepalensis, Betula alnoides, Carpinus viminea, Abies densa, Berberis spp., Pinus wallichiana, Schima, Litsea sp. etc.*	
		Middle Storey: Bamboo in the east	
		Lower Storey: Evergreen shrubs	
		14/C2 East Himalayan Sub-Alpine Birch/Fir Forest	**13.46**
		Top Storey: *Abies densa, Juniperus wallichiana*	
		Middle Storey: *Rhododendron wightii, Betula utilis, Rhododendron spp., Pyrus aucuparia, Salix wallichiana*	
		Lower storey: *Spiraea sp., Juniperusrecurva, Cassiope fastigiata, Rhododendron lepidotum, Potentilla fruticosa, Polygonum sp.*	

3	Assam	**2B/C2 Cachar Semi-Evergreen Forest Cachar, Assam**	**37.75**
		Top Storey/ Middle Storey: *Artocarpus chaplasha, Dipterocarpus turbinatus, Palaquium polyanthum, Cynometra polyandra, Eugenia spp., Vitex peduncularis, Pterospermum acerifolium, Pterygota alata, Chukrasia velutina, Tetrameles nudiflora, Adina cordifolia, Protium serratum, Albizia procera, Premna bengalensis, Gmelina arborea, Salmalia insignis, Stereospermum personatum* and many others	
		Middle Storey: *Melocanna bambusoides*	
		Lower Storey: Evergreen shrubs	
		3C/C3b East Himalayan Moist Mixed Deciduous Forest	**17.92**
		Top Storey: *Lagerstroemia parviflora, Terminalia bellirica, Sterculia villosa, Salmalia malabarica, Schima wallichii*	
		Middle Storey: *Careya arborea, Bauhinia purpurea, Amoora spp.*	
		1B/C1 Assam Valley Tropical Wet Evergreen Forest (Dipterocarpus)	**3.56**
		Top Storey: *Dipterocarpus macrocarpus, Shorea assamica, Mesua ferrea, Altingia excelsa, Dysoxylum procerum, Artocarpus chaplasha, Michelia spp., Stereospermum personatum, Canarium spp., Amoora wallichii*	
		Middle Storey: *Vatica lanceifolia, Eugenia spp., Garcinia cowa, Talauma spp., Myristica spp., Dendrocalamus hamiltonii, Bambusa pallida, Pseudostachyum polymorphum, Linistona jenkinsiana*	
		Lower storey: *Clerodendron, Ixora, Pinanga, Laportea*	
4	Bihar	**5B/C2 Northern Dry Mixed Deciduous Forest Singhbhum, Bihar (Cochlospermum-Euphorbia association)**	**30.7**
		Top Storey & Middle Storey: *Lannea coromandelica, Gardenia latifolia, Cochlospermum religiosum, Sterculia urens, Chloroxylon swietenia, Buchanania lanzan, Aegle marmelos, Anogeissus latifolia, Morinda tinctoria, Canthium dicoccum, Emblica officinalis, Euphorbia nivulia, Protium serratum, Lagerstroemia parviflora, Erythrina suberosa, Stereospermum suaveolens, Ficus spp.* **Lower Storey:** *Woodfordia fruticosa, Nyctanthes arbor-tristis, Petalidium barlerioides, Murraya paniculata, Sarcostemma acidum, Eranthemum purpurascens, Justicia spp., Rungia, Dicliptera sp., Butea superba, Olax scandens, Jasminum, Erycibe*	

		Singhbhum, Bihar (Anogeissus-Mitragyna-Dendrocalamus - Daedalacanthus association)	
		Top & Middle storey: *Anogeissus latifolia, Adina cordifolia, Mitragyna parvifolia, Hymenodictyon excelsum, Aegle marmelos, Chloroxylon swietenia, Schleichera oleosa, Lannea coromandelica, Schrebera swietenioides, Lagerstroemia parviflora, Bridelia retusa, and occasional Shorea, Cochlospermum, Sterculia, Boswellia, Buchanania, Ougeinia oojeinensis, Erythrina, Bauhinia malabarica, Madhuca, Diospyros montana, Stereospermum, Vitex peduncularis* **Lower Storey:** *Petalidium barlerioides, Helicteres isora, Strobilanthes auriculatus, Symphorema polyandrum*	
		5B/C1c Dry Peninsular Sal Forest Singhbhum, Bihar	**21.13**
		(1) Shorea-Anogeissus-Woodfordia association **Top & Middle Storey:** *Shorea robusta, Anogeissus latifolia, Boswellia serrata, Cochlospermum religiosum, Dillenia aurea, Ziziphus xylopyrus, Gardenia gummifera.* ***Lower Storey:*** *Woodfordia fruticosa, Wendlandia tinctoria, Grewia hirsuta, Phoenix acaulis* **(2) Shorea-Gardenia-Eulaliopsis association** **Top & Middle Storey:** *Shorea robusta, Buchanania lanzan, Eugenia caryophyllifolia, Gardenia gummifera, Madhuca indica, Diospyros tomentosa, Emblica officinalis. Cephalostachyum pergracile* **Lower Storey:** *Wendlandia tinctoria, Phoenix acaulis*	
		5B/C1a Dry Siwalik Sal Forest	**5.14**
		Top Storey: *Shorea robusta, Anogeissus latifolia* **Middle Storey:** *Buchanania lanzan* **Lower Storey:** *Woodfordia fruticosa, Indigofera pulchella*	
5	**Chhattisgarh**	**5A/C3 Southern Dry Mixed Deciduous Forest** **Top & Middle Storey:** *Terminalia tomentosa, Anogeissus latifolia, Mitragyna parvifolia, Schrebera swietenioides, Madhuca indica, Diospyros tomentosa, Buchanania lanzan, Lagerstroemia parviflora, Emblica officinalis, Cassia fistula, Aegle marmelos, Butea monosperma, Santalum album, Albizia spp., Boswellia serrata, Chloroxylon swietenia, Syzygium cumini, Hardwickia binata, Acacia arabica, Prosopis juliflora, Sterculia urens* **Lower Storey:** *Nyctanthes arbor-tristis, Ziziphus spp., Helicteres isora, Vitex negundo, Adhatoda vasica, Gymnosporia spinosa, Randia dumetorum, Flacourtia indica, Grewia spp., Woodfordia fruticosa, Balanites aegyptiaca, Carissa spp., Holarrhena antidysenterica, Lantana camara*	**27.37**
		3C/C2e (ii) Moist Peninsular Low Level Sal Forest **Top Storey:** *Shorea robusta, Terminalia tomentosa, Pterocarpus marsupium, Anogeissus latifolia, Madhuca indica* **Middle Storey:** *Emblica officinalis, Buchanania lanzan, Diospyros melanoxylon, Terminalia chebula, Kydia calycina, Ougeinia oojeinensis, Bridelia retusa, Bauhinia retusa, Dendrocalamus strictus*	**16.64**

		Lower Storey: *Nyctanthes arbor-tristis, Ziziphus spp., Helicteres isora, Vitex negundo, Adhatoda vasica, Gymnosporia spinosa, Randia dumetorum, Flacourtia indica, Grewia spp., Woodfordia fruticosa, Balanites aegyptiaca, Carissa spp., Holarrhena antidysenterica, Lantana camara*	
		3B/C2 SouthernMoist Mixed Deciduous Forest **Top Storey:** *Pterocarpus marsupium, Salmalia malabarica, Terminalia bellirica, Anogeissus latifolia, Dalbergia latifolia, Terminalia tomentosa, Lannea coromandelica, Madhuca indica, Garuga pinnata* **Middle Storey:** *Miliusa tomentosa, Polyalthia cerasoides, Lagerstroemia parviflora, Emblica officinalis, Xylia xylocarpa, Grewia tiliifolia, Schrebera swietenioides, Cleistanthus collinus, Diospyros montana, Flacourtia indica, Dendrocalamus strictus* **Lower Storey:** *Ziziphus oenopolia, Casearia graveolens, Helicteres isora, Desmodium gangeticum*	**15.68**
6	**Delhi**	**6B/C2 Ravine Thorn Forest** **Top & Middle Storey:** *Acacia senegal, A. leucophloea, Prosopis spicigera, Salvadora oleoides* **Lower Storey:** *Capparis decidua, Ziziphus mauritiana, Z. nummularia, Calotropis procera*	**45.37**
		5B/C2 Northern Dry Mixed Deciduous Forest **Top Storey:** *Acacia catechu, Anogeissus latifolia, Lannea coromandelica, Aegle marmelos, Feronia limonia, Ehretia laevis, Kydia calycina, Ougeinia oojeinensis, Mitragyna parvifolia, Flacourtia indica* **Middle Storey:** *Mallotus philippensis, Nyctanthes arbor- tristis, Dendrocalamus strictus* **Lower Storey:** *Carissa opaca, Dodonaea viscosa, Woodfordia fruticosa, Adhatoda vasica*	**21.73**
7	**Goa**	**3B/C2 Southern Moist Mixed Deciduous Forest** **Top Storey:** *Adina cordifolia, Grewia tiliifolia, Madhuca indica, Dillenia pentagyna, Cinnamomum spp., Litsea spp., Olea dioica, Terminalia paniculata, Tectona grandis, Grewia tilifolia, Careya arborea* **Middle Storey:** *Emblica officinalis, Xylia xylocarpa etc., Bambusa arundinacea, Dendrocalamus strictus* **Lower Storey:** *Tabernaemontana spp. Ziziphus rugosa, Cyclea, Acacia concinna*	**42.55**
		1A/C4 West Coast Tropical Evergreen Forest **Top Storey:** *Dipterocarpus indicus, Poeciloneuron indicum, Mesua ferrea, Hopea parviflora, Dysoxylum malabaricum, Calophyllum elatum, Machilus macranthus, Palaquium ellipticum* and many others. **Middle Storey:** *Myristica sp., Euphoria longana, Unona pannosa, Humboldtia brunonis, Aglaia odoratissima, Hopea wightiana, Oxytenanthera spp.* **Lower Storey:** *Rubiaccae, Strobilanthes, Pinanga dichsoni, Arenga wightii, Pandanus, Calamus spp*	**22.4**

		2A/C2 West Coast Semi-Evergreen Forest **Top Storey:** *Terminalia paniculata, Diospyros spp., Lagerstroemia lanceolata, Holigarna arnottiana, Lophopetalum wightianum, Machilus macranthus, Cinnamomum sp., Hopea parviflora, Artocarpus hirsutus* **Middle Storey:** *Elaeocarpus serratus, Mallotus philippensis, Diospyros assimilis, Ixora arborea* **Lower Storey:** *Webera, Strobilanthes spp., Ixora malabarica.* Climbers and canes numerous	**21.35**
8	**Gujarat**	**5A/C3 Southern Dry Mixed Deciduous Forest** **Top Storey/ Middle Storey:** *Sterculia urens, Lannea coromandelica, Salmalia malabarica, Moringa oleifera* **Lower Storey:** *Euphorbia tirucalli, Capparis decidua, Lawsonia inermis*	**12.75**
		5A/C1b Dry Teak Forest **Top Storey:** *Tectona grandis, Boswellia serrata, Lannea coromandelica, Anogeissus latifolia, Diospyros tomentosa, Terminalia tomentosa, Butea monosperma, Hymenodictyon excelsum, Cochlospermum religiosum, Cassia fistula, Bauhinia racemosa, Bridelia retusa, Ougeinia oojeinensis, Dalbergia latifolia, Schrebera swietenioides* **Middle Storey:** *Wrightia tinctoria, Flacourtia indica, Ziziphus xylopyrus, Dendrocalamus strictus* **Lower Storey:** *Holarrhena antidysenterica, Nyctanthes arbor-tristis, Ziziphus nummularia*	**11.77**
		6B/C1 Desert Thorn Forest **1. Kutch, Saurashtra, Gujrat** **Top Storey:** *Acacia senegal, A. leucophloea, Cordia rothii, Azadirachta indica* **Middle Storey & Lower Storey:** *Euphorbia neriifolia, E. nivulia, Balanites aegyptiaca, Salvadora, Commiphora mukul, Capparis spp., Grewia tenax, G. villosa, Premna integrifolia* **2. Sasan, Saurashtra, Gujrat** *Acacia planifrons, A. arabica, A. catechu, Balanites aegyptica, Ziziphus spp.*	**9.22**
9	**Haryana**	**5B/C2 Northern Dry Mixed Deciduous Forest** **Top Storey:** *Acacia catechu, Anogeissus latifolia, Lannea coromandelica, Aegle marmelos, Feronia limonia, Ehretialaevis, Kydia calycina, Ougeinia oojeinensis, Mitragyna parvifolia, Flacourtia indica* **Middle Storey:** *Mallotus philippensis, Nyctanthes arbor- tristis, Dendrocalamus strictus* **Lower Storey:** *Carissa opaca, Dodonaea viscosa, Woodfordia fruticosa, Adhatoda vasica*	**30.2**
		6B/C2 Ravine Thorn Forest **Top Storey & Middle Storey:** *Acacia senegal, A. leucophloea, Prosopis spicigera, Salvadora oleoides* **Lower Storey:** *Capparis decidua, Ziziphus mauritiana, Z. nummularia, Calotropis procera*	**14.32**
		6/1S1 Desert Dune Scrub **Top Storey:** *Prosopis spicigera, Acacia arabica, Tamarix aphylla, Salvadora oleoides* **Middle Storey/Lower Storey:** *Calotropis gigantea, C. procera, Ziziphus nummularia, Z. mauritiana, Calligonum polygonoides, Balanites aegyptiaca, Capparis decidua, Leptadenia pyrotechnica, Aerva javanica, Crotalaria burhia*	**6.4**

10	**Himachal Pradesh**	**12/C1d Western Mixed Coniferous Forest (Spruce, Blue Pine, Silver Fir)** **Top Storey:** *Picea spp., Cedrus deodara, Abies pindrow, Pinus wallichiana* **Middle Storey:** *Quercus dilatata, Quercus incana, Quercus semecarpifolia, Acer acuminatum, A. caesium, A. pictum, Euonymus lacerus, Taxus baccata, Betula alnoides, Arundinaria falcata, Thamnocalamus spathiflorus* **Lower Storey:** *Deutzia corymbosa, Ribes rubrum, Viburnum nervosum, Skimmia, Strobilanthes spp. Va. Fragaria, Viola, Valeriana, Pteridium, Adiantum venustum, Aspidium aculeatum*	**14.03**
		15/C3 Alpine Pasture *Agropyron longearistatum, A. semicostatum, Brachypodium sylvaticum, Bromus asper, B. japonicus, Dactylis sp., Danthonia sp., Festuca sp., Milium effusum, Oryzopsis, Phleum, Poa spp. etc.*	**13.96**
		5B/C2 Northern Dry Mixed Deciduous Forest **Top Storey:** *Acacia catechu, Anogeissus latifolia, Lannea coromandelica, Aegle marmelos, Feronia limonia, Ehretialaevis, Kydia calycina, Ougeinia oojeinensis, Mitragyna parvifolia, Flacourtia indica* **Middle Storey:** *Mallotus philippensis, Nyctanthes arbor- tristis, Dendrocalamus strictus* **Lower Storey:** *Carissa opaca, Dodonaea viscosa, Woodfordia fruticosa, Adhatoda vasica*	**12.7**
11	**Jammu & Kashmir and Ladakh (combined)**	**12/C1d Western Mixed Coniferous Forest (Spruce, Blue Pine, Silver fir)**	
		Top Storey: *Picea, Cedrus deodara, Abies pindrow, Pinus wallichiana* **Middle Storey:** *Quercus dilatata, Quercus incana, Quercus semecarpifolia, Acer acuminatum, A. caesium, A. pictum, Euonymus lacerus, Taxus baccata, Betula alnoides, Arundinaria falcata, Thamnocalamus spathiflorus* **Lower Storey:** *Deutzia corymbosa, Ribes rubrum, Viburnum nervosum, Skimmia, Strobilanthes sp. Va. Fragaria, Viola, Valeriana, Pteridium, Adiantum venustum, Aspidium aculeatum*	**12.82**
		9/C1a Lower or Siwalik Chir Pine Forest	
		Top Storey: *Pinus roxburghii* **Middle Storey:** *Terminalia chebula, Mallotus philippensis, Pyrus pashia, Syzygium cumini, Albizia chinensis, Emblica, Acacia catechu* **Lower Storey:** *Carissa opaca, Dodonaea viscosa, Rubus ellipticus, Crataegus crenulata, Flacourtia, Myrsine africana, Woodfordia fruticosa, Colebrookia, Berberis, Indigofera pulchella, Murraya koenigii*	**10.86**
		NOTE- In moister sites, *Quercus incana, Quercus glauca, Pyrus, Rhododendron etc*	
		12/C1c Moist Deodar Forest (Cedrus) **Top Storey:** *Cedrus deodara, Pinus wallichiana* **Middle Storey:** *Quercus incana* **Lower Storey:** *Rosa macrophylla, Berberis lycium, Lonicera angustifolia, Strobilanthes wallichii, Boenninghausenia spp., Deutzia staminea*	**8.93**

12	Jharkhand	**5B/C1c Dry Peninsular Sal Forest** **(1) Shorea-Anogeissus-Woodfordia association** **Top Storey & Middle Storey:** *Shorea robusta, Anogeissus latifolia, Boswellia serrata, Cochlospermum religiosum, Dillenia aurea, Ziziphus xylopyrus, Gardenia gummifera* **Lower Storey:** *Woodfordia fruticosa, Wendlandia tinctoria, Grewia hirsuta, Phoenix acaulis* **(2) Shorea-Gardenia-Eulaliopsis association** **Top & Middle Storey:** *Shorea robusta, Buchanania lanzan, Eugenia caryophyllifolia, Gardenia gummifera, Madhuca indica, Diospyros tomentosa, Emblica officinalis, Cephalostachyum pergracile* **Lower Storey:** *Wendlandia tinctoria, Phoenix acaulis*	**53.77**
		5B/C2 Northern Dry Mixed Deciduous Forest **(i) Cochlospermum-Euphorbia association** **Top & Middle Storey:** *Lannea coromandelica, Gardenia latifolia, Cochlospermum religiosum, Sterculia urens, Chloroxylon swietenia, Buchanania lanzan, Aegle marmelos, Anogeissus latifolia, Morinda tinctoria, Canthium dicoccum, Emblica officinalis, Euphorbia nivulia, Protium serratum, Lagerstroemia parviflora, Erythrina suberosa, Stereospermum suaveolens, Ficus spp.* **Lower Storey:** *Woodfordia fruticosa, Nyctanthes arbor- tristis, Petalidium barlerioides, Murraya paniculata* **(ii) Anogeissus-Mitragyna-Dendrocalamus- Daedalacanthus** association **Top & Middle Storey:** *Anogeissus latifolia, Adina cordifolia, Mitragyna parvifolia, Hymenodictyon excelsum, Aegle marmelos, Chloroxylon swietenia, Schleichera oleosa, Lannea coromandelica, Schrebera swietenioides, Lagerstroemia parviflora, Bridelia retusa, and occasional Shorea, Cochlospermum, Sterculia, Boswellia, Buchanania, Ougeinia oojeinensis, Erythrina, Bauhinia malabarica, Madhuca, Diospyros montana, Stereospermum, Vitex peduncularis* **Lower Storey:** *Petalidium barlerioides, Helicteres isora, Strobilanthes auriculatus, Symphorema polyandrum*	**35.01**
		5/DS1 Dry Deciduous Scrub *Acacia catechu, Butea monosperma, Randia dumetorum, Carissa opaca, Acacia pennata, Flacourtia indica, Euphorbia, Ziziphus, Carissa, Mimosa*	**2.36**
13	Karnataka	**1A/C4 West Coast Tropical Evergreen Forest** **Top Storey:** *Dipterocarpus indicus, Poeciloneuron indicum, Mesua ferrea, Hopea parviflora, Dysoxylum malabaricum, Calophyllum elatum, Machilus macranthus, Palaquium ellipticum and many others* **Middle Storey:** *Myristica sp., Euphoria longana, Unona pannosa, Humboldtia brunonis, Aglaia odoratissima, Hopea wightiana, Oxytenanthera spp.*	**12.65**
		Lower Storey: *Rubiaccae, Strobilanthes, Pinanga dichsoni, Arenga wightii, Pandanus*	
		3B/C2 Southern MoistMixed Deciduous Forest **Top Storey:** *Adina cordifolia, Grewia tiliifolia, Madhuca indica, Dillenia pentagyna, Cinnamomum, Litsea, Oleadioica* **Middle Storey:** *Emblica officinalis, Xylia xylocarpa, Bambusa arundinacea, Dendrocalamus strictus* **Lower Storey**: *Tabernaemontana,Ziziphus rugosa, Cyclea, Acacia concinna*	**11.70**

		2A/C2 West Coast Semi-Evergreen Forest **Top Storey:** *Terminalia paniculata, Diospyros spp., Lagerstroemia lanceolata, Holigarna arnottiana, Lophopetalum wightianum, Machilus macranthus, Cinnamomum sp., Hopea parviflora, Artocarpus hirsutus* **Middle Storey:** *Elaeocarpus serratus, Mallotus philippensis, Diospyros assimilis, Ixora arborea* **Lower Storey:** *Webera, Strobilanthes spp., Ixora malabarica*	**10.52**
14	**Kerala**	**1A/C4 West Coast TropicalEvergreen Forest** **1. High Level Evergreen Forests of Wynaad, Kerala-** These forests are characterised by a high proportion of Mesua ferrea, Palaquium ellipticum, Cullenia excelsa and Calophyllum elatum. The absence of *Dioterocarpus indicus, Filicium, Kingiodendron pinnatum* and *Hopea* is noteworthy; these species are met with at lower elevations in the adjoining Kannoth block, where *Merua* is absent. **Top Storey:** *Palaquium ellipticum, Vateria, (especially near water courses), Calophyllum elatum, Cullenia excelsa, Dysoxylum malabaricum, Artocarpus hirsutus, Cedrelatoona, Machilus macranthus, Mesua ferrea, Elaeocarpus tuberculatus, Bischofia, Eugenia spp., Canarium* **Middle Storey:** *Palaquium ellipticum, Moristica spp., Vateria, Eugenia munroi, Actinodaphne hirsuta, Ostodes, Euphoria longana, Litseaspp, Meliosm simplicifolia, Polvalthia coffeoides, Cinnamomum zeylanicum, Elaeocarpus serratus*, Bamboos appear mainly as Ochlandra brakes along the larger streams but occasionally spread out on the slopes. **Lower Storey:** *Leea indica, Rubiaceae, Apama, Areca, Strobilanthes spp., Psychotria, Lasianthus, Pandanus sp., Glycosmis, Calamus sp., Laportea crenulata, Large ferns*	**15.13**
		2. High Level Evergreen Forests of Nilambur (Kerala) **Top Storey:** *Palaquium ellipticum, Cullenia excelsa, Calophyllum elatum, Terminalia bellirica, Machilus macranthus, Dysoxylum malabaricum, Elaeocarpus tuberculatus, Artecarpus hirsutus* **Middle Storey:** *Eugenia gardneri, Cinnamomum zeylanicum, Bischofia javanica, Cedrela toona, Elaeocarpus sp., Xylopia parviflora., Ochlandra spp.* **Lower Storey:** *Strobilanthes, Rubiaceae, Pinanga dicksonii, Arenga wightii* **NOTE.** Here Palaquium is the commonest species. Hopea is found sparsely, scattered below 750 m. Mesua ferrea is abundant from 9oo m. to 1,200 m. Calophyllum tends to be gregarious in patches. Dipterocarpus is absent	
		2A/C2 West Coast Semi-Evergreen Forest	**13.79**
		i) Wynaad and Palghat, Kerala **Top Storey:** *Artocarpus hirsutus, Salmalia malabarica, Vitex altissima, Tetrameles nudiflora, Acrocarpus fraxinifolius, Hopea parviflora, Lagerstroemia lanceolata, Vateria indica, Anthocephalus cadamba, Xylia xylocarpa, Terminalia tomentosa, Cedrela toona, Grewia tiliifolia, Dalbergia latifolia, Pterospermum rubiginosum, Radermachera xylocarpa, Mesua ferrea, Adina cordifolia, Holoptelea integrifolia, Pterocarpus marsupium, Sterculia guttata* **Middle Storey:** *Hydnocarpus laurifolia, H. alpina, Bischofia javanica, Mallotus philippensis, Kydia calycina, Schleichera oleosa, Evodia lunuankenda, Bambusa arundinacea, Ochlandra spp.*	

		(ii) Trivandrum, Kerala- Top Storey: *Artocarpus hirsutus, Hopea parviflora, Adina cordifolia, Lagerstroemia lanceolata, Terminalia paniculata, T. tomentosa, Salmalia malabarica, Tetrameles nudiflora, Vitex altissima, Holoptelea integrifolia, Vateria indica, Lophopetalum, Pterocarpus marsupium, Calophyllum elatum, Machilus macranthus, Grewia tiliifolia, Terminalia bellirica* **Middle Storey:** *Polyalthia fragrans, Canarium strictum, Cinnamomum zeylanicum, Aporosa lindleyana, Mallotus philippensis, Xanthophyllum flavescens, Emblica officinalis, Bridelia retusa, Albizia odoratissima.* Bamboos and reeds very common. **Lower Storey:** *Clerodendron, Glycosmis pentaphylla, Strobilanthes sp.*	
		3B/C2 Southern Moist Mixed Deciduous Forest	**8.80**
		Top Storey: *Terminalia paniculata, T. tomentosa, T. bellirica, Pterocarpus marsupium, Albizia procera, Alstonia scholaris, Dillenia pentagyna, Bridelia retusa, Salmalia malabarica, Grewia tiliifolia* **Middle Storey:** *Xylia xylocarpa, Careya arborea, Callicarpa lanata, Cassia fistula, Strychnos nux-vomica* **Lower Storey:** *Croton reticulatus, Anisomeles heyneana, Carissa carandas*	
		Ranni, Kerala- **Top & Middle Storey:** *Terminalia paniculata, T. tomentosa, Pterocarpus marsupium, Anogeissus latifolia, Careya arborea, Buchanania lanzan, Emblica officinalis, Dillenia pentagyna, Salmalia insignis, Sterculia villosa, Albizia odoratissima, Cassia fistula, Gmelina arborea, Taberaemontana heyneena, Bauhinia malabarica, Wrightia tinctoria*	
15	**Madhya Pradesh**	**5A/C1b Dry Teak Forest**	**26.40**
		Top Storey /Middle Storey: *Tectona grandis, Anogeissus latifolia, Diospyros tomentosa. Pterocarpus marsupium, Dalbergia latifolia, Cassia fistula, Butea monosperma, Adina cordifolia, Mitragyna parvifolia, Bridelia retusa, Aegle marmelos, Lagerstroemia parviflora, Wrightia tinctoria, Bauhinia spp., Alangium salviifolium, Dendrocalamus strictus* **Lower Storey:** *Nyctanthes arbor-tristis, Woodfordia fruticosa, Helicteres isora, Grewia hirsuta, Gymnosporia spinosa, Indigofera pulchella, Adhatoda vasica, Carissa spp., Holarrhena antidysenterica, Lantana camara*	
		5A/C3 Southern Dry Mixed Deciduous Forest	**24.55**
		Top Storey /Middle Storey: *Terminalia tomentosa, Anogeissus latifolia, Mitragyna parvifolia, Schrebera swietenioides, Madhuca indica, Diospyros tomentosa, Buchanania lanzan, Lagerstroemia parviflora, Emblica officinalis, Cassia fistula, Aegle marmelos, Butea monosperma, Santalum album,Albizia spp., Boswellia serrata, Chloroxylon swietenia, Syzygium cumini, Hardwickia binata, Acacia arabica, Prosopis juliflora, Sterculia urens* **Lower Storey:** *Nyctanthes arbor-tristis, Ziziphus spp., Helicteres isora, Vitex negundo, Adhatoda vasica, Gymnosporia spinosa, Randia dumetorum, Flacourtia indica, Grewia spp., Woodfordia fruticosa, Balanites aegyptiaca, Carissa spp., Holarrhena antidysenterica, Lantana camara*	
		5B/C2 Northern Dry Mixed Deciduous Forest **Top Storey & Middle Storey:** *Anogeissus pendula, Acacia catechu, Anogeissus latifolia, Diospyros melanoxylon, Madhuca indica, Butea monosperma, Emblica officinalis, Feronia limonia, Albizia spp., Acacia leucophloea, A. arabica, Soymida febrifuga, Miliusa tomentosa, Bauhinia spp., Dendrocalamus strictus* **Lower Storey:** *Carissa sp., Flacourtia indica, Ziziphus xylopyrus, Ziziphus nummularia, Capparis decidua, Calotropis procera, Falanites aegyptiaca, Holarrhena antidysenterica, Grewia spp., Adhatoda vasica, Gymnosporia spinosa*	**18.55**

16	Maharashtra	**5A/C3 Southern Dry Mixed Deciduous Forest** **Top Storey /Middle Storey:** *Boswellia serrata, Acacia leucophloea, Bauhinia tomentosa, Rhus mysorensis, Lannea coromandelica, Flacourtia indica, Cochlospermum religiosum, Anogeissus latifolia, Terminalia tomentosa, Gymnosporia spinosa, Ziziphus mauritiana, Ziziphus oenopolia, Ziziphus xylopyrus, Azadirachta indica, Santalum album, Osyris wightiana, Tectona grandis, Heterophragma quadriloculare, Stereospermum personatum, Dolichandrone falcata*	**26.3**
		3B/C2 Southern Moist Mixed Deciduous Forest **Top Storey**: *Tetrameles nudiflora, Stereospermum personatum, Dysoxylum binectariferum, Ficus nervosa (all occasional).* **Middle Storey:** *Syzygium cumini, Olea dioica, Pouteria tomentosa, Bridelia retusa var. squamosa, Mangifera, Actinodaphne angustifolia, Ficus glomerata, Memecylon umbellatum, Mallotus, Ixora, Flacourtia, Randia* **Lower Storey:** *Callicarpa, Lasiosiphon, Phaylopsis, Leea, Pogostemon etc.*	**21.01**
		(ii) Chanda, Maharashtra- **Top Storey**: *Pterocarpus marsupium, Salmalia malabarica, Terminalia bellirica, Anogeissus latifolia, Dalbergia latifolia, Terminalia tomentosa, Lannea coromandelica, Madhuca indica, Garuga pinnata* **Middle Storey:** *Miliusa tomentosa, Polyalthia cerasoides, Lagerstroemia parviflora, Emblica officinalis, Xylia xylocarpa, Grewia tiliifolia, Schrebera swietenioides, Cleistanthus collinus, Diospyros montana, Flacourtia indica, Dendrocalamus strictus* **Lower Storey:** *Ziziphus oenopolia, Casearia graveolens, Helicteres isora, Desmodium gangeticum*	
		5A/C1b Dry Teak Forest **Top Storey:** *Tectona grandis, Terminalia tomentosa, Lannea coromandelica, Diospyros tomentosa, Madhuca indica, Miliusa tomentosa, Anogeissus latifolia, Soymida febrifuga, Mitragyna parvifolia, Boswellia serrata, Hardwickia binata, Dalbergia paniculata, Dillenia pentagyna* **Middle Storey:** *Butea monosperma, Buchanania lanzan, Emblica officinalis, Cassia fistula, Acacia catechu, Bauhinia racemosa, Holarrhena antidysenterica, Flacourtia indica, Randia dumetorum, Dendrocalamus strictus* **Lower Storey:** *Helicteres isora, Calotropis gigantea, Grewia sp., Woodfordia fruticosa, Nyctanthes arbor-tristis*	**17.40**
17	Manipur	**8B/C1 East Himalayan Sub-Tropical Wet Hill Forest** **a) Langool Reserve. Quercus-Laurus-Schima hylium, 800, to 1,000 m. or more.** **Top Storey:** *Lithocarpus spicatus, Quercus vercus (fenestrata), Quercus serrata, Castanopsis, Schima, Cinnamomum, Saurauia spp., Litsea spp., Machilus, Syzygium, Cedrela toona* **Middle Storey/Lower Storey:** *Psychotria, Flacourtia, Symplocos, Crateva nurvala, and Emblica* **(b) Ukhrul and Shugnu. Pinus-Quercus hylium, 1,200 to 1,500 m., 1,750 mm. rainfall, volacanic rock.** **Top Storey:** *Pinus insularis* (khasya) dominant. **Middle Storey:** *Quercus spp., Lithocarpus, Schima, Castanopsis spp., Betula alnoides, Acer oblongum, Engelhardia spp., Symplocos* **Lower Storey:** *Pittosporum sp., Myrsine, Debregeasia, Rubus spp., etc.* **(c) Koupru and Maohing. Saurauia-Phoebe-Beilschmiedia hylium, 900 to 1,800 m., 3,000 to 4,000 mm. rainfall.** **Top Storey/Middle Storey:** *Saurauia sp., Phoebe lanceolata, Beilschmiedia, Cinnamomum cecicodaphne, Schima, Lauraceae (many spp.), Ostodes* **Lower Storey:** Abundant shrub layer	**33.69**

		3C/C3b East Himalayan Moist Mixed Deciduous Forest **Top Storey:** *Lagerstroemia parviflora, Terminalia bellirica, Sterculia villosa, Salmalia malabarica, Schima wallichii* **Middle Storey:** *Careya arborea, Bauhinia purpurea, Amoora spp.*	**24.48**
		2B/C2 Cachar Semi-Evergreen Forest **Kabaw Valley, Manipur. 100 m. (DEB)-** **Top Storey:** *Dipterocarpus tuberculatus, D. turbinatus, Melanorrhoea usitata, Duabanga grandiflora, Xylia dolabriformis, Dillenia pentagyna, Lagerstroemia parviflora, Terminalia tomentosa, Gmelina arborea* **Middle Storey:** *Terminalia citrina, Emblica officinalis, Engelhardia spicata, Saurauia nepaulensis, Symplocos racemosa, Mallotus philippensis, Melocanna bambusoides* **Lower Storey:** *Wendlandia grandis, Woodfordia fruticosa, Buddleia asiatica, Indigofera pulchella, Leea spp., Desmodium spp., Licuala peltata*	**15.39**
18	**Meghalaya**	**3C/C3b East Himalayan Moist Mixed Deciduous Forest** **Top Storey:** *Lagerstroemia parviflora, Terminalia bellirica, Sterculia villosa, Salmalia malabarica, Schima wallichii* **Middle Storey:** *Careya arborea, Bauhinia purpurea, Amoora spp.*	**47.73**
		8B/C2 Khasi Sub-Tropical Wet Hill Forest **Top Storey:** *Quercus spp., Manglietia insignis, Beilschmiedia spp., Cinnamomum spp., Machilus spp., Schima khasiana, Bucklandia, Ficus nemoralis* **Middle Storey:** *Lindera spp., Ilex spp., Ligustrum spp., Litsea spp., Prunus spp., Pyrus spp., Symplocos spp., Myrica sapida, Lyonia spp., Chimonobambusa callosa* **Lower Storey:** *Myrsine semiserrata, Daphne spp., Euonymus spp., Hypericum spp., Viburnum spp., Zanthoxylum spp., Rosa spp., Rubus spp.*	**20.43**
		1B/C3 Cachar Tropical Evergreen Forest **Top Storey & Middle Storey:** *Palaquium, Diospyros topiosa, Cynometra polyandra, Dipterocarpus turbinatus, Mesua, Eugenia spp., Euphoria longana, Sapium baccatum, Vatica lanceifolia, Canarium spp., Hydnocarpus kurzii, Heritiera acuminata, Kayea floribunda*	**8.52**
19	**Mizoram**	**2/2S1 Secondary Moist Bamboo Brakes** *Melocanna bambusoides. Bambusa tulda, Dendrocalamus hamiltonii*	**37.42**
		3C/C3b East Himalayan Moist Mixed Deciduous Forest **Top Storey:** *Lagerstroemia parviflora, Terminalia bellirica, Sterculia villosa, Salmalia malabarica, Schima wallichii* **Middle Storey:** *Careya arborea, Bauhinia purpurea, Amoora spp.*	**30.79**
		2B/C2 Cachar Tropical Semi-Evergreen Forest **Top Storey & Middle Storey:** *Palaquium, Diospyros topiosa, Cynometra polyandra, Dipterocarpus turbinatus, Mesua, Eugenia spp., Euphoria longana, Sapium baccatum, Vatica lanceifolia, Canarium spp., Hydnocarpus kurzii, Heritiera acuminata, Kayea floribunda*	**30.70**
20	**Nagaland**	**3C/C3b East Himalayan Moist Mixed Deciduous Forest** **Top Storey:** *Lagerstroemia parviflora, Terminalia bellirica, Sterculia villosa, Salmalia malabarica, Schima wallichii* **Middle Storey:** *Careya arborea, Bauhinia purpurea, Amoora spp.*	**38.44**

		2B/2S2 Eastern Alluvial Secondary Semi-Evergreen Forest **Top Storey:** *Ailanthus grandis, Pterospermum, Albizia lucida, Stereospermum, Terminalia citrina, T. bellirica, Dipterocarpus macrocarpus, Anthocephalus* **Middle Storey:** *Macaranga, Mallotus albus, Zanthoxylum, Alstonia, Actinodaphne, Litsea monopetala, Bambusa pallida, Pseudostachyum, Dendrocalamus hamiltonii* **Lower Storey:** *Laportea, Melastoma*	**17.55**
		8B/C2 Khasi Sub-Tropical Wet Hill Forest **Top Storey:** *Quercus spp., Manglietia insignis, Beilschmiedia, Cinnamomum spp., Machilus spp., Schima khasiana, Bucklandia, Ficus nemoralis* **Middle Storey:** *Lindera spp., Ilex spp., Ligustrum spp., Litsea spp., Prunus spp., Pyrus spp., Symplocos spp., Myrica sapida, Lyonia spp., Chimonobambusa callosa* **Lower Storey:** *Myrsine semiserrata, Daphne spp., Euonymus spp., Hypericum spp., Viburnum spp., Zanthoxylum spp., Rosa spp., Rubus spp.*	**16.09**
21	**Odisha**	**3C/C2e (ii) Moist Peninsular Low Level Sal** **Top Storey:** *Shorea robusta, Terminalia tomentosa, Adina cordifolia, Mitragyna parvifolia, Lagerstroemia parviflora, Anogeissus latifolia, Bridelia retusa, Albizia procera, Hymenodictyon excelsum, Pterocarpus marsupium, Salmalia malabarica, Gmelina arborea* **Middle Storey:** *Cleistanthus collinus, Dalbergia latifolia, Dalbergia paniculata, Syzygium cumini, Dillenia pentagyna, Careya arborea, Diospyros spp., Mallotus philippensis, Dendrocalamus strictus* **Lower Storey:** *Cipadessa fruticosa, Woodfordia fruticosa, Clerodendrum viscosum, Ziziphus oenopolia*	**22.06**
		5B/C2 Northern Dry Mixed Deciduous Forest **Top Storey:** *Adina cordifolia, Lagerstroemia parviflora, Anogeissus latifolia, Terminalia tomentosa, Mitragyna parvifolia, Dalbergia latifolia, Hymenodictyon excelsum, Bridelia retusa, Albizia spp., Salmalia malabarica, Shorea robusta, Pterocarpus marsupium, Dalbergia paniculata, Protium serratum, Stereospermum suaveolens, Terminalia bellirica, Melia composita, Cleistanthus collinus, Diospyros tomentosa, Lannea coromandelica* **Middle Storey:** *Ougeinia oojeinensis, Cassia fistula, Alangium salviifolium, Careya arborea, Holarrhena antidysenterica, Casearia tomentosa, Mallotus philippensis, Randia spp., Feronia limonia, Acacia leucophloea, Ziziphus xylopyrus, Chloroxylon swietenia, Gardenia latifolia, Dendrocalamus strictus* **Lower Storey:** *Helicteres isora, Strobilanthes spp., Moghania, Gardenia gummifera*	**21.29**
		5B/C1c Dry Peninsular Sal Forest **Top Storey:** *Shorea robusta, Terminalia tomentosa, Pterocarpus marsupium, Anogeissus latifolia, Lagerstroemia parviflora, Adina cordifolia, Terminalia bellirica, Acacia catechu, Buchanania lanzan* **Middle Storey:** *Cleistanthus collinus, Chloroxylon swietenia, Emblica officinalis, Cassia fistula, Terminalia chebula, Wendlandia tinctoria, Symplocos racemosa, Dendrocalamus strictus* **Lower Storey:** *Indigofera pulchella, Phoenix acaulis*	**17.79**
22	**Punjab**	**5B/C2 Northern Dry Mixed Deciduous Forest** **Top Storey:** *Acacia catechu, Anogeissus latifolia, Lannea coromandelica, Aegle marmelos, Feronia limonia, Ehretialaevis, Kydia calycina, Ougeinia oojeinensis, Mitragyna parvifolia, Flacourtia indica* **(i) Kangra Division, Punjab-** **Middle Storey:** *Mallotus philippensis, Nyctanthes arbor- tristis, Dendrocalamus strictus* **Lower Storey:** *Carissa opaca, Dodonara viscosa, Woodfordia fruticose, Adhatoda vasica*	**67.29**

		6B/C2 Ravine Thorn Forest **Top Storey & Middle Storey:** *Acacia senegal, A. leucophloea, Prosopis spicigera, Salvadora oleoides* **Lower Storey:** *Capparis decidua, Ziziphus mauritiana, Z. nummularia, Calotropis procera, Tephrosia purpurea*	**4.17**
		5/E9 Dry Bamboo Brakes *Dendrocalamus strictus*	**1.62**
23	**Rajasthan**	**5B/C2 Northern Dry Mixed Deciduous Forest** **(i) Chittorgarh Division, Rajasthan-** **Top Storey:** *Anogeissus latifolia, Boswellia serrata, Terminalia tomentosa, Sterculia urens, Lannea coromandelica, Diospyros melanoxylon, Albizia odoratissima, Soymida febrifuga, Cassia fistula, Bridelia retusa, Bauhinia racemosa, Mitragyna parvifolia, Butea monosperma, Ficus spp., Dalbergia paniculata* **Middle Storey:** *Acacia catechu, Acacia leucophloea, Nyctanthes arbor-tristis, Ziziphus mauritiana, Prosopis spicigera, Wrightia tinctoria, Flacourtia indica, Dendrocalamus strictus* **Lower Storey:** *Carissa spinarum, Ziziphus nummularia, Grewia spp.* **(ii) Udaipur Division, Rajasthan-** **Top Storey & Middle Storey:** *Anogeissus latifolia, Boswellia serrata, Lannea coromandelica, Sterculia urens, Terminalia arjuna, Salmalia malabarica, Soymida febrifuga, Albizia odoratissima, Acacia leucophloea, Emblica officinalis, Wrightia tinctoria, Mitragyna parvifolia* **Lower Storey:** *Holarrhena antidysenterica, Vitex negundo, Woodfordia fruticosa, Jatropha spp.*	**40.07**
		5/E1 Anogeissus pendula Forest **Top Storey & Middle Storey:** *Anogeissus pendula, Boswellia serrata, Acacia catechu, A. rupestris, Albizia odoratissima, Dalbergia lanceolaria, Dichrostachys cinerea, Bauhinia racemose, Grewia spp.*	**15.21**
		5/E1/DS1 Dry Deciduous Scrub **Top Storey & Middle Storey:** *Nyctanthes arbor-tristis, Dodonaea viscosa, Woodfordia fruticosa, Carissa opaca, Flacourtia indica, Lannea coromandelica, Aegle marmelos, Cassia fistula, Acacia catechu*	**10.96**
24	**Sikkim**	**14/C2 East Himalayan Sub-alpine birch/fir forest** **Gompatung Chu, Sikkim, 2,800 m.-** **Top Storey:** *Abies densa, Juniperus wallichiana* **Middle Storey:** *Rhododendron wightii, Betula utilis, Rhododendron spp., Pyrus aucuparia, Salix wallichiana* **Lower Storey:** *Spiraea sp., Juniperus recurva, Cassiope fastigiata, Rhododendron lepidotum, Potentilla fruticosa, Polygonum sp.*	**24.01**
		8B/C1 East Himalayan Sub-tropical wet hill forest **Top Storey:** *Phoebe paniculata, P. attenuata, Beilschmiedia roxburghiana, Engelhardtia, Nyssa javanica, Schima wallichii, Chinnamomum cecicodaphne, Morus laevigata, Syzygium cumini, Quercus fenestrata, Calophyllum polyanthum, Wightia, etc.* **Middle Storey:** *Drypetes venusta, Talauma hodgsonii, Gynocardia odorata, Nyssa javanica, Garcinia paniculata, Eugenia kurzii, Dendrocalamus patellaris, Chimonobambusa griffithiana* **Lower Storey:** *Daphne, Cyclea, Glycosmis, Strobilanthes spp., Phlogacanthus etc.*	**23.89**

25	Tamil Nadu	**5A/C3 Southern Dry Mixed Deciduous Forest** **Top Storey:** *Shorea talura, Dalbergia latifolia, Terminalia tomentosa, T. chebula, T. paniculata, Pterocarpus marsupium, Albizia odoratissima, Anogeissus latifolia, Cassia fistula, Hardwickia binata, Santalum album* **Middle Storey:** *Dendrocalamus strictus* **Top Storey and Middle Storey:** *Hardwickia binata, Anogeissus latifolia, Chloroxylon swietenia, Erythroxylon monogynum, Acacia catechu*	**22.43**
		5/2S1 Secondary Dry Deciduous Forest **Top Storey:** *Salmalia malabarica, Buchanania lanzan, Grewia tiliifolia, Elacodendron glaucum, Schleichera oleosa, Lannea coromandelica, Semecarpus anacardium, Tectona grandis* **Middle Storey:** *Feronia limonia, Aegle marmelos, Ziziphus xylopyrus, Careya arborea, Gardenia spp., Dolichandrone atrovirens, Santalum album* **Lower Storey:** *Dodonaea viscosa, Carissa spinarum, Holarrhena antidysenterica, Lantana*	**9.91**
		6A/C1 Southern Thorn Forest **Top Storey & Middle Storey:** *Chloroxylon swietenia, Albizia amara, Acacia chundra, A. ferruginaca, Azadirachta indica, Canthium dicoccum, Erythroxylon monogynum, Ziziphus mauritiana, Z. xylopyrus, Cleistanthus collinus, Dichrostachys cinerea, Atalantia monophylla*	**6.85**
26	Telangana	**5A/C3 Southern Dry Mixed Deciduous Forest** **Top Storey:** *Terminalia tomentosa, Bauhinia racemosa, Acacia arabica, A. catechu, Boswellia serrata, Buchanania lanzan, Azadirachta indica, Ougelnia oojeinensis, Flacourtia indica* **Middle Storey:** *Gymnosporia spinosa, Ziziphus mauritiana, Z. xylopyrus, Morinda tinctoria* **Lower Storey:** *Mimosa hamata, Terminalia tomentosa, Grewia hirsuta*	**60.52**
		5B/DS1 Dry Deciduous Scrub Scattered *Acacia leucophloea, Bauhinia racemosa, Dalbergia paniculata, Wrightia tinctoria, Ziziphus xylopyrus, Cassia fistula, Randia, Annona, Heteropogon contortus, Eragrostis spp.*	**19.21**
		5A/C1b Dry Teak Forest **Top Storey:** *Tectona grandis, Pterocarpus marsupium, Anogeissus latifolia, Dalbergia latifolia, Terminalia tomentosa, Chloroxylon swietenia, Lannea coromandelica, Dalbergia paniculata, Salmalia malabarica, Terminalia bellirica, Madhuca indica, Lagerstroemia parviflora, Boswellia serrata, Sterculia urens* **Middle Storey:** *Diospyros tomentosa, Buchanania lanzan, Acacia chundra, Acacia leucophloea, Aegle marmelos, Soymida febrifuga, Wrightia tinctoria, Butea monosperma, Cleistanthus collinus, Ziziphus xylopyrus* **Lower Storey:** *Randia dumetorum, Cassia auriculata, Nyctanthes arbor-tristis, Helicteres isora, Ziziphus spp.*	**14.84**
27	Tripura	**3C/C3b East Himalayan Moist Mixed Deciduous Forest** **Top Storey:** *Lagerstroemia parviflora, Terminalia bellirica, Sterculia villosa, Salmalia malabarica, Schima wallichii* **Middle Storey:** *Careya arborea, Bauhinia purpurea, Amoora spp.*	**39.89**
		2B/C2 Cachar Semi-Evergreen Forest **Top Storey & Middle Storey:** *Palaquium, Diospyros topiosa, Cynometra polyandra, Dipterocarpus turbinatus, Mesua, Eugenia spp., Euphoria longana, Sapium baccatum, Vatica lanceifolia, Canarium spp., Hydnocarpus kurzii, Heritiera acuminata, Persea owdenii, Kayea floribunda*	**27.47**
		2/2S1 Secondary Moist Bamboo Brakes *Dendrocalamus hamiltonii*	**7.55**

28	Uttar Pradesh	**5B/C2 Northern Dry Mixed Deciduous Forest** **Top Storey:** *Anogeissus latifolia, Boswellia serrata, Acacia catechu, Shorea robusta, Bauhinia spp., Cochlospermum religiosum, Terminalia tomentosa, Buchanania lanzan, Diospyros tomentosa, Terminalia bellirica, Hymenodictyon excelsum, Garuga pinnata, Kydia calycina, Sterculia pallens, Mitragyna parvifolia, Bridelia retusa* **Middle Storey:** *Nyctanthes arbor-tristis, Gardenia turgida, Ougeinia oojeinensis, Ehretia laevis, Aegle marmelos, Emblica officinalis, Feronia limonia, Holarrhena antidysenterica, Cordia dichotoma, Ziziphus xylopyrus, Wendlandia exserta, Cassia fistula, Casearia tomentosa, Butea monosperma, Flacourtia indica, Ziziphus mauritiana, Dendrocalamus strictus* **Lower Storey:** *Woodfordia fruticosa, Nyctanthes arbor- tristis, Indigofera pulchella*	**34.90**
		3C/C2d (i) WesternLight Alluvium Plains Sal **(i) North Kheri Division, Uttar Pradesh-** **Top Storey:** *Shorea robusta, Terminalia tomentosa, T. bellirica, Lagerstroemia parviflora, Adina cordifolia, Kydia calycina, Stereospermum suaveolens, Schleichera oleosa, Ficus spp.* **Middle Storey:** *Syzygium cumini, Miliusa velutina, Semecarpus anacardium, Bauhinia malabarica, Grewia spp., Mallotus philippensis, Butea monosperma, Holarrhena antidysenterica* **Lower Storey:** *Helicteres isora, Ardisia solanacea, Moghania, Clerodendrum viscosum, Murraya koenigii* **(ii) SouthKheri Division, Uttar Pradesh-** **Top Storey:** *Shorea robusta, Terminalia tomentosa, Lagerstroemia parviflora, Diospyros tomentosa, Stereospermum suaveolens, Madhuca indica* **Middle Storey:** *Buchanania lanzan, Bridelia retusa, Syzygium malabarica, Aegle marmelos* **Lower Storey:** *Carissa spinarum, Ziziphus mauritiana, Ziziphus oenopolia, Helicteres isora*	**10.06**
		6B/C2 Ravine Thorn Forest **Top Storey:** *Acacia leucophloea, Prosopis spicigera, Azadirachta indica, Holoptelea integrifolia, Acacia arabica, Salvadora oleoides, Balanites aegyptiaca, Flacourtia indica* **Middle Storey:** *Capparis decidua, C. sepiaria, C. zeylanica Carissa opaca, Ziziphus spp., Dichrostachys cinerea, Calotropis procera, Adhatoda vasica*	**5.11**
29	Uttarakhand	**9/C1b Upper or Himalayan Chir Pine Forest** **Top Storey:** *Pinus roxburghii* **Middle Storey:** *Ficus roxburghii, Syzygium cumini, Engelhardtia colebrookiana, Lyonia ovalifolia, Quercus incana, Rhododendron arboreum, Symplocos crataegoides, Myrica sapida* **Lower Storey:** *Indigofera dosua, Flemingia fruticulose, Lespedeza sericea, Rubus ellipticus, Viburnum coriaceum, Glochidion velutinum, Leptodermis lanceolata, Aechmanthera tomentosa*	**27.97**
		3C/C2a Moist Siwalik Sal Forest **Top Storey:** *Shorea robusta, Anogeissus latifolia, Terminalia tomentosa, Adina cordifolia, Pinus roxburghii, Lannea coromandelica, Garuga pinnata, Terminalia bellirica, Diospyros tomentose* **Middle Storey:** *Ougeinia oojeinensis, Buchanania lanzan, Semecarpus anacardium, Ehretia laevis, Bauhinia spp., Cassia fistula, Casearia tomentosa, Emblica officinalis, Olea glandulifera, Engelhardia colebrookeana, Machilus odoratissima, Dendrocalamus strictus* **Lower Storey:** *Colebrookia oppositifolia, Murraya koenigii, Woodfordia fruticosa, Berberis asiatica, Indigofera pulchella, Clerodendrum viscosum, Pogostemon plectranthoides*	**14.05**

		12/C1a Ban Oak Forest (Q. incana) **Top Storey:** *Quercus incana, Carpinus viminea, Cedrela serrata* **Middle Storey:** *Rhododendron arboreum, Lyonia ovalifolia, Euonymus pendulus, Ilex dipyrena, Betula alnoides, Lindera pulcherrima, Litsea umbrosa* **Lower Storey:** *Viburnum cotinifolium, Desmodium tiliaefolium, Indigofera gerardiana, Rubus niveus, Boenninghausenia spp., Myrsine africana, Deutzia staminea*	**13.86**
30	**West Bengal**	**5B/C1c Dry Peninsular Sal Forest** **1) Shorea-Anogeissus-Woodfordia association** **Top Storey & Middle Storey:** *Shorea robusta, Anogeissus latifolia, Boswellia serrata, Cochlospermum religiosum, Dilleniaaurea, Ziziphus xylopyrus, Gardenia gummifera* **Lower Storey:** *Woodfordia fruticosa, Wendlandia tinctoria, Grewia hirsuta, Phoenix acaulis* **(2) Shorea-Gardenia-Eulaliopsis association** **Top Storey & Middle Storey:** *Shorea robusta, Buchanania lanzan, Eugenia caryophyllifolia, Gardenia gummifera, Madhuca indica, Diospyros tomentosa, Emblica officinalis, Cephalostachyum pergracile* **Lower Storey:** *Wendlandia tinctoria, Phoenix acaulis*	**16.31**
		4B/TS2 Mangrove Forest **(i) W. Sunderbans-** **Top Storey/Middle Storey:** *Rhizophora candelaria, Kandelia candel, Avicennia alba, Bruguiera conjugata, Xylocarpus moluccensis (Carapa), Ceriops tagal, Lumnitzera racemosa, Xylocarpus granatum, Excoecaria agallocha, Ceriops roxburghiana, Sonneratia apetala* **(ii) Krishna and Godavari deltas** **Top Storey/Middle Storey:** *Avicennia officinalis, Rhizophora mucronata, R. candelaria, Ceriops roxburghiana, Bruguiera spp., Sonneratia apetala* **Lower Storey:** *Acanthus ilicifolius, Clerodendrum inerme*	**5.89**
		4B/TS3 Salt Water Mixed Forest (Heritiera) **Top Storey/Middle Storey:** *Heritiera minor, Excoecaria agallocha, Ceriops roxburghiana, Xylocarpus moluccensis, Bruguiera conjugata, Avicennia officinalis, Amoora cucullata, Aegialitis rotundifolia* **Lower Storey:** *Nipa* relatively uncommon	**2.8**
31	**Andaman & Nicobar Islands**	**1A/C2 Andamans Tropical Evergreen Forest** **(i) Andamans** **Top Storey:** *Dipterocarpus grandiflorus, D. pilosus, Artocarpus chaplasha, A. gomezianus, Calophyllum soulattri, Planchonia andamanica, Hopea odorata, Endospermum chinense, Sideroxylon longipetiolatum* **Middle Storey:** *Xanthophyllum andamanicum, Myristica andamanica, M. glaucescens, Baccaurea sapida, Croton argyratus, Pterospermum aceroides, Caryota mitis, Cryptocarya, Memecylon spp., Euphorbia epiphylloides, Pseuduvaria prainii, Actephila excelsa* **Lower Storey:** *Anaxagorea luzonensis, etc.*	**43.70**
		(ii) Gopalkabang valley, South Andamans **Top Storey:** *Dipterocarpus kerrii, D. grandiflorus, D. gracilis* **Middle Storey:** *Artocarpus, Planchonia, Hopea odorata, Pterospermum aceroides, Myristica andamanica, Elaeocarpus sp.* **Lower Storey:** *Oxytenanthera nigrociliata, Macaranga andamanica, Mussaenda macrophylla, Leea sp., Evodia glabra, Licuala peltata, Pandanus, Clinogyne grandis*	

		2A/C1 Andamans Semi-Evergreen Forest **Top Storey:** *Dipterocarpus alatus, D. pilosus, Pterygota alata,Pterocymbium tinctorium, Sterculia campanulata, Terminalia bialata, T. procera, Albiziachinensis, A. lebbek, Calophyllum soulattri, Salmalia insignis, Artocarpus lakoocha, A. chaplasha, Pterocarpus dalbergioides* **Middle Storey:** *Lagerstroemia hypoleuca, Dillenia pentagyna, Dracontomelum mangiferum, Pometia pinnala, Myristica irya, Pisonia excelsa, Litsea panamonja, Xanthophyllum andamanicum, Fagraea morindaefolia, Talauma andamanica, Garcinia andamanica, Aporosa villosula, Licuala peltata, Caryota mitis, Areca triandra* **Middle Storey:** Usually no bamboos. Oxytenanthera sp. **Lower Storey:** *Saprosma ternata, Maesa andamanica, Micromelum pubescens, Clerodendrum viscosum, Leea indica, Clinogyne grandis*	**29.30**
		4B/TS2 Mangrove Forest **Andaman Islands:** *Rhizophora mucronata, R. candelaria, Bruguiera conjugata, B. parviflora, Avicennia officinalis, Ceriops tagal, Kandelia candel, Xylocarpus moluccensis, Sonneratia caseolaris, Excoecaria spp., etc.* **Great Nicobar Islands:** *Bruguiera conjugata, Carallia brachiata, Sonneratia caseolaris, Nipa fruticans, Areca triandra*	**10.96**
32	**Chandigarh**	**5B/C2 Northern Dry Mixed Deciduous Forest** **Top Storey:** *Acacia catechu, Anogeissus latifolia, Lannea coromandelica, Aegle marmelos, Feronia limonia, Ehretialaevis, Kydia calycina, Ougeinia oojeinensis, Mitragyna parvifolia, Flacourtia indica* **Middle Storey:** *Mallotus philippensis, Nyctanthes arbor- tristis, Dendrocalamus strictus, Carissa opaca, Dodonara viscosa, Woodfordia fruticose, Adhatoda vasica*	**48.33**
		5B/DS1 Dry Deciduous Scrub **Top Storey:** *Nyctanthes arbor-tristis, Dodonaea viscosa, Woodfordia fruticosa, Carissa opaca, Flacourtia indica, Lannea coromandelica, Aegle marmelos, Cassia fistula, Acacia catechu*	**0.09**
33	**Dadra & Nagar Haveli**	**3B/C2 Southern Moist Mixed Deciduous** **Top Storey:** *Adina cordifolia, Grewia tiliifolia, Madhuca indica, Dillenia pentagyna, Cinnamomum, Litsea, Olea dioica.* **Middle Storey:** *Emblica officinalis, Xylia xylocarpa, Bambusa arundinacea, Dendrocalamus strictus, Tabernaemontana spp. etc.*	**77.66**
		3B/C1b Moist Teak Forest **Top Storey:** *Tectona grandis, Terminalia tomentosa, Adina cordifolia, Dalbergia latifolia, Madhuca indica, Pterocarpus marsupium, Mitragyna parvifolia, Lagerstroemia parviflora, Albizia spp., Salmalia malabarica, Diospyros tomentosa, Careya arborea, Stereospermum personatum, Tamarindus indica* **Middle Storey:** *Xylia xylocarpa, Grewia tiliifolia, Cleistanthus collinus, Emblica officinalis, Schleichera oleosa, Diospyros montana, Ixora arborea* **Lower Storey:** *Dendrocalamus strictus, Helicteres isora, Petalidium barlerioides, Pogostemon plectranthoides, Indigofera spp.*	**9.44**
		5A/C3 Southern Dry Mixed Deciduous **Top Storey/Middle Storey:** *Boswellia serrata, Acacia leucophloea, Bauhinia tomentosa, Rhus mysorensis, Lannea coromandelica, Flacourtia indica, Cochlospermum religiosum, Anogeissus latifolia, Terminalia tomentosa* **Lower Storey:** *Gymnosporia spinosa, Ziziphus mauritiana, Ziziphus oenopolia, Z. xylopyrus, Azadirachta indica, Santalum album, Osyris wightiana, Tectona grandis, Heterophragma quadriloculare, Stereospermum personatum, Dolichandrone falcata*	**4.31**

34	Daman & Diu	**4B/TS2 Mangrove Forest** *Rhizophora mucronata, R. candelaria, Bruguiera conjugata, B. parviflora, Avicennia officinalis, Ceriops tagal, Kandelia candel, Xylocarpus moluccensis, Sonneratia caseolaris, Excoecaria spp., etc.*	**14.79**
		6B/C1 Desert Thorn forest **Top Storey:** *Acacia senegal, A. leucophloea, Cordia roth* **Middle Storey:** *Azadirachta indica, Euphorbia nivulia, Balanites aegyptiaca, Salvadora, Commiphora mukul, Capparis spp., Grewia tenax, G. villosa, Premna integrifolia*	**14.45**
		4A/L1 Littoral Forest **Top Storey:** *Casuarina equisetifolia, Calophyllum inophyllum, Terminalia catappa* **Middle Storey:** Barringtonia asiatica, Erythrina variegata, Guettarda speciosa, Pongamia pinnata, Heritiera littoralis, Cerbera manghas, Ochrosia oppositifolia **Middle Storey:** Ixora spp., Cycas rumph, Asplenium nidus, Dendrobium spp., Bulbophyllum spp. **Top Storey/Middle Storey:** *Hibiscus tiliaceus, Thespesia populnea, Erythrina variegata, Ixora arborea, Vitex negundo, V. trifolia, Trewia nudiflora, Dolichandrone spathacea*	**6.69**
35	Puducherry	**4B/TS2 Mangrove Forest** *Rhizophora mucronata, R. candelaria, Bruguiera conjugata, B. parviflora, Avicennia officinalis, Ceriops tagal, Kandelia candel, Xylocarpus moluccensis, Sonneratia caseolaris, Excoecaria spp. etc.*	**3.19**

Indian Council of Forestry Research and Education
(An Autonomous Body of Ministry of Environment, Forest & Climate Change)
Government of India
P.O. New Forest, Dehradun, Uttarakhand-248006