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Guidelines for Development of Miyawaki Forest

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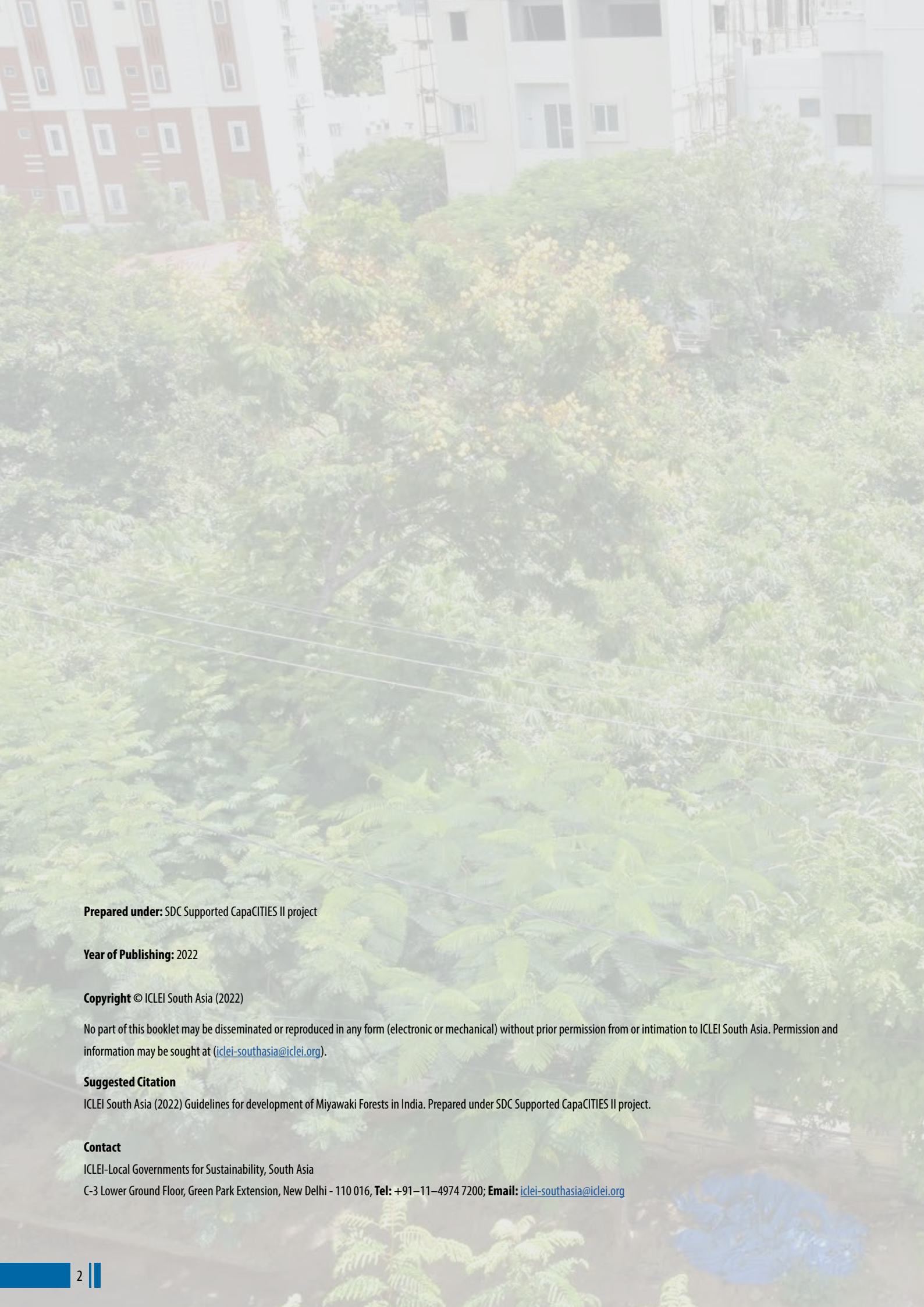

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Contents

Origin of Miyawaki Technique

Dr. Akira Miyawaki, a vegetation ecologist is widely known for introducing the Miyawaki technique of growing forests around the world[1]. The Miyawaki technique is based on the concept of Potential Natural Vegetation (PNV) and deals with the regeneration of a forest by closely planting a variety of tree species, best suited for the specified locality. The Miyawaki technique of growing forests, also referred to as the potted seedling method[2], refers to an ecological engineering approach meant for restoring natural forests using the seeds of native trees, on a degraded patch of land[3].

The concept of PNV was developed by Reinhold Tuexen, a German vegetation ecologist, in 1956[1]. It is defined as "a concept used to investigate and evaluate the theoretical potential of the natural environment of an area that may have had its environmental and geographical conditions modified by human activities over time". The concept is regarded as useful in the growing of native vegetation. In the 1950s, Dr. Akira Miyawaki learnt about the PNV concept, biocoenosis[4] and phytosociology (also known as plant sociology) while doing an extensive field research, studying the vegetation types and ecosystems of the past in Germany[1]. After returning to Japan at the end of 1950s, Dr. Akira Miyawaki implemented his learnings of the concept to compile current and potential natural vegetation maps of the country as well as a major publication called "Vegetation of Japan". The extensive survey and research which led to these publications also helped Dr. Miyawaki establish the basis for his lifelong study of nature and restoring natural vegetation worldwide.

Furthermore, trees and natural vegetation existing in sacred groves or community forests i.e. "Chinju-no-Mori" of Japan proved to be of great importance to Dr. Miyawaki, in assessing the PNV of different regions of Japan in order to fulfil the purpose of restoring native forests in the country as a measure to protect nature[1]. These community forests also helped in determining information about the multi tree layer community comprising of the main tree species (canopy), the sub tree species (sub-canopy), shrubs (undergrowth) and herbs (ground vegetation). After the field assessments conducted in the Japanese Archipelago, the results show that the potential natural vegetation in the region comprised of evergreen broad-leaved trees such as Castanopsis, persea, and evergreen oak, excluding the mountain areas of Tohoku and Hokkaido. The study also yielded that only 0.06 percent of the evergreen forests remained in the region.

Understanding the need for halting environmental degradation as a result of rising economic activity and pollution in Japan, Dr. Akira Miyawaki's research became widely recognized as a means to protect nature[1]. In 1971, using the scientific knowledge of PNV concept, phytosociology and the multi tree layer system, Dr. Akira Miyawaki created the first naturally bio-diverse forest on the factory site of Nippon Steel Corporation. The method used to create such a forest, thereafter, came to be known as the Miyawaki technique and the forest developed using this method, the Miyawaki forest.

Benefits of Miyawaki Technique as Opposed to Normal Plantations

Miyawaki technique of growing forests is regarded as the most effective plantation method for quickly renewing degraded lands. Given below are the benefits of Miyawaki method of growing forests as opposed to normal plantations[5].

1. Miyawaki technique is a unique methodology which comprises of pre-determined steps and procedures of planting trees. On the other hand, normal plantations do not have a set of defined procedure involving soil and site analysis, etc. which may prove to be a disadvantage in the development stages of a plant.
2. The number of trees planted through Miyawaki technique are approximately 30 times more than the number of trees planted through traditional plantation technique. This is because as per the Miyawaki method, the sapling density is maintained at about 3 to 4 plant per sq. m. whereas normally, trees are planted with a spacing of at least 3 meters. Therefore, tree density per sq. m. is largely high in forests planted through the Miyawaki method as compared to normal plantation method.
3. A minimum of 300 percent more species is found in the region where forest is regenerated through Miyawaki technique in comparison to the number of species found in conventional plantations. This can largely be attributed to the fact that high tree density along with a high nativity rate leads to rich biodiversity. A Miyawaki forest is thus a biodiverse region and provides habitat to a distinctive group of flora and fauna as compared to area with normal plantations.
4. As opposed to traditional plantations, it has been found that there is a 3000 percent increase in noise and dust isolation in forests grown through the Miyawaki technique. Since the Miyawaki forests are dense in comparison to the normal plantations, they are able to mitigate noise and air pollution more effectively. Also, dust particles are less likely to sieve through a dense forest, as compared to normal plantations.
5. Forests grown through Miyawaki technique absorbs up to 30 times more carbon dioxide than a plantation that is grown conventionally. As Miyawaki plantations are more biodiverse, they tend to sequester more carbon in comparison to normal plantations.

6. In Miyawaki plantations, there is a guaranteed growth of at least 1 meter every year, in tree height. This is due to good soil quality, soil organic content and better land productivity as opposed to plantations raised normally.

7. Miyawaki technique yields a completely maintenance free, wild and native forest after the first three years of plantation. On the other hand, normal plantations, if not provided with adequate after-care, may tend to dieback or grow poorly. Miyawaki technique therefore ensures healthy growth of trees with minimal chances of failure.

8. Miyawaki forests are completely chemical-fertilizer free, that sustain themselves and support native biodiversity. In contrast, plantations are raised with the heavy inputs of chemical pesticides and fertilizers, which has other adverse impacts on the environment.

How to Develop a Miyawaki Forest - Steps Suggested by Dr. Akira Miyawaki

Development of Miyawaki forest involves an ecological engineering approach using the forest reconstruction method[6]. The method is based on the knowledge of the following[6]:

1. **The potential natural vegetation of the site:** Potential vegetation refers to "an abstract concept of a vegetation made up of the plant species present in remnants of the plant cover, without human influence"[7]. A thorough analysis of the existing vegetation type, local topography and an understanding of inter and intra species relationships, as well as with the surrounding environment helps in determining the potential vegetation of the site. Information about the potential vegetation of a site is important to reconstruct a forest with native tree species that mimics the functioning of a natural forest.

2. **Germination and establishment biology of seeds from specimen plants in a nursery:** For the purpose of developing strong root systems to increase the rate of seedling survival in a forest, collection of seeds of the specimen plants which comprise the potential vegetation is important. This will help to ensure successful seed germination in the nursery. For this, seeds need to be sown in pots, and after a period of two years, the seedlings should be planted at the actual site.

3. **Procedure of planting of seedlings in a forest:** The final procedure of planting seedlings in a forest includes the following steps:

- Site preparation: This step involves the plowing of soil on site to prepare the surface for planting of seedlings. Planting beds or low mounds of soil should be created to check harm caused due to flooding or heavy rains. In addition, mulching of planting beds with straws and organic fertilizer should be carried out to avoid potential damage to the seedlings.
- Planting of seedlings: The process of planting seedlings in a forest is specifically ceremonious in nature in Japan and largely community-driven. This helps to instill ecological values amongst the people as well as to develop a forest with a "complex pattern of trees". Volunteers and participants should be guided to plant seedlings in pre-dug holes, followed by spreading of mulch around the planting mound.
- Post-plantation care: The method does not necessarily require further site maintenance after the plantation of seedlings. As has been observed, the success rate of survival of seedlings in the first year is more than 90% and the forest tends to grow fast such that a closed canopy is developed within a span of five years. The method also facilitates a natural competition between species thereby leading to a development of a quasi-natural Miyawaki forest.

MIYAWAKI FOREST – KEY STATISTICS

Planting Density:	3 to 7 trees per m^2
Green Surface Area:	30 times more than a meadow
Survival rate (Natural Selection):	15% – 90%
Growth rate:	1.5 m/year (rainforest), 1 m/year (temperate forest), 0.3 m/year (Mediterranean forest)
Growth stabilization:	From 15-20 years (temperate zone), 30-40 years (tropical zone)
Final average size:	20 m (upper layer or emergent/canopy layer of a forest), 4m (lower layer or understory)
Density after stabilization:	0.5 to 2.5 trees per m^2
Biodiversity (fauna):	18 times more (mean of different species)

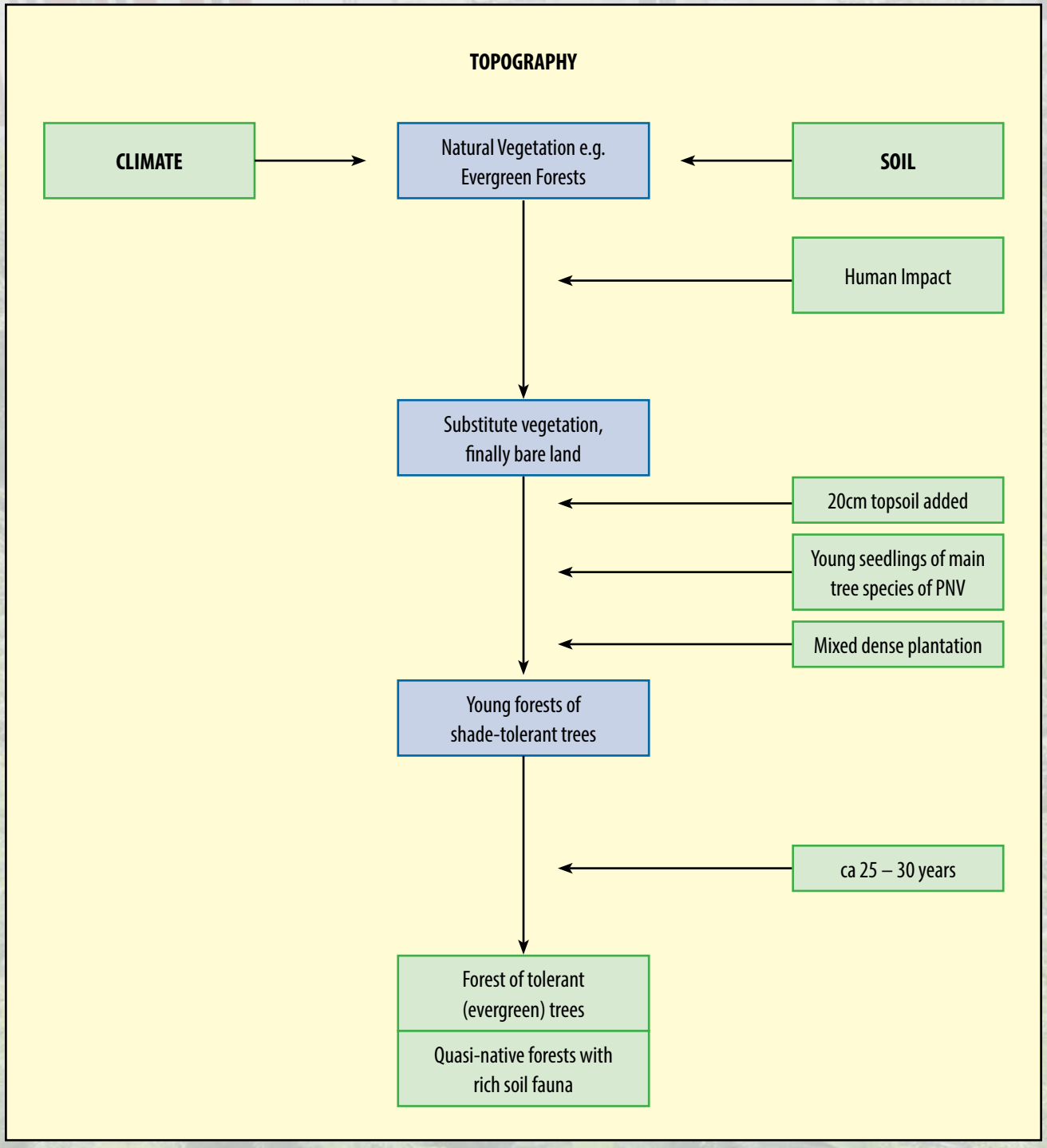

Figure 1: Diagrammatic representation of Miyawaki's succession theory[8]

Development of Miyawaki Forests – Process being followed by some Organisations

The Miyawaki technique of developing forests is being used successfully across the globe[9]. This method is being used to develop dense patches of native trees in the form of small urban forests, avenue plantations, shelterbelts and windbreaks. This section provides a glimpse of such work being carried out by a few organisations in India and in other parts of the world.

Forest Creators

This organisation is based out of Mumbai, India. They strive to create "Miyawaki Forests that are 100% organic, wild, fast growing and self-sustainable". They believe in shifting from manicured landscapes to purpose-based plantations that contribute to conservation of natural resources such as air, water and soil, check climate change and global warming and supporting the overall well-being of the planet. For the creation of compact and modular Miyawaki forests, Forest Creators follow these steps:

- Soil and water testing for selected sites: The results of the same are used to select the tree species and also determine the required soil treatment.
- Identification of tree species for site: Since the Miyawaki technique focuses on planting of native tree species, species that are native to the region are selected.
- Procurement of material and saplings: Material required for plantations such as organic manure and saplings are procured from the nursery.
- Soil preparation as per Miyawaki methodology: Special emphasis is given to enhancing the soil's water retention capacity, perforation and soil nutrient content.
- Miyawaki method of cluster plantation: About 3-4 saplings in 1 sq. m area are planted. Cluster plantations having different tree species are planted in close proximity to each other.
- Maintenance and growth monitoring: Regular watering and weeding is done for two years post which the forest becomes self-sustained.

Acacia Eco

Based out of Ahmedabad, India, this organisation has the vision to work on implementing greening solutions to increase urban forests and mass plantations. The organization also aims to "create sustainable urban forests using a scientific approach; including techniques like the Miyawaki Forestation method, which has been proven to work in adverse soil and climate conditions and have faster and more sustainable growth compared to traditional plantation techniques".

The agency started with a pilot project in March 2016 to understand the Miyawaki technique and assess the growth results. Since then, they have expanded to various other areas in the country to develop Miyawaki forests.

Acacia Eco follows the following steps for development of Miyawaki forests:

- Soil and water testing for selected sites: This is done for tree species selection and soil treatment requirements.
- Identification of tree species: Desirable and site-specific tree species are identified based on the soil/water, type of site and client preferences.
- Material procurement: Chemical-free fertilizers, organic manure and saplings are procured from nurseries. Saplings with height range between 6-12 inches are planted on the site.
- Soil preparation: Soil is prepared as per the Miyawaki methodology i.e. the water retention capacity of the soil, perforation and soil organic/nutrient content is enhanced for better soil productivity and better growth.
- Miyawaki method of cluster plantation: Cluster plantations bearing various kinds of tree species are planted in close proximity (3 to 4 trees in 1 sq. m. area).
- Maintenance and growth monitoring: This includes regular de-weeing and is carried out for two years post plantation.

Afforestt

Afforestt is based out of Bangalore and New Delhi, India. They are "a service provider for creating natural, wild, maintenance free, native forests". Established in January 2011 as a for profit social enterprise, they have a vision to bring back the native forests through the use of Miyawaki technique. Their aim is to provide end to end service of transforming a barren or a degraded piece of land into a lush green forest within a period of three years.

The organisation creates Miyawaki forest based on the following steps:

- Procurement of seeds: Seeds are sourced from natural forests.
- Seed germination: Seeds are germinated in a nursery. Initially sown in beds, the sprouted seedlings (with two or three leaves) are transplanted to pots. They are kept in pots until their roots fill the containers
- Sapling preparation: The saplings are cultivated under nets designed to cut out 60 percent of the sunlight for one or two months. Later they are cultivated under nets designed to cut out 40 percent of the sunlight for one or two months. Following this, the saplings are subject to the natural environment in an existing forest, for acclimatization, for a period of between one week to one month.
- Maintenance: Post plantation maintenance is carried out for one or two years. No maintenance is carried out from the third year onwards. At this point, the rule is "No management is the best management".

Boomforest

Based out of Paris, France, Boomforest promotes the creation of native forests, without maintenance, in every landscape. including urban areas. They are involved in stimulating the reforestation process using the Miyawaki plantation method.

They incentivize project cooperation among different actors of reforestation and the restoration of biodiversity. Miyawaki forest is developed using the following steps:

- Site survey and understanding the Potential Natural Vegetation: Identification of the native species 20 km around the plantation site for the purpose of afforestation is carried out. Identification of 50 to 100 different species is recommended, which need to be transported to a nearby nursery.
- Terrain preparation: This step includes soil cleaning, addition of organic nutrients, preparation of elements permitting water retention and the creation of a hill with a slope of 30 degrees maximum.
- Plantation by the volunteers: About 3 to 5 tree saplings are planted per square meter. Straw protection is also applied to allow the creation of wood humidity and water retention.
- Maintenance: Watering and weed control is carried out for three years. The dead plants and weeds are reused in the form of straw for putting it on the top of the hill.
- After 3 years of basic supervision, forest site is left to itself to grow.

Urban Forests

They are the Miyawaki method specialists in Europe and use the Miyawaki method to create urban forests. They believe that while it takes about 200 years to let a forest recover on its own, with the Miyawaki method a similar result is achieved in 20 years. The agency believes in creating a Miyawaki forest that grows each year by a minimum of 1 meter, without chemicals or synthetic fertilizers.

Given below are the steps followed by Urban Forests to create a Miyawaki forest:

- Plantation: Seedlings are planted densely, 3 trees/m2 and randomly (not in line), mixing as many native trees of potential natural vegetation as possible.
- Establishment of seedlings: Approximately three years after planting, natural selection among the seedlings allows the most adapted ones to develop quickly.
- After15-20 years of planting, the early model of a dense mature forest gets established.

Guidelines for Development of Miyawaki Forest

The success and benefits of the Miyawaki technique have made it a very popular method across the globe. Like in all countries, city governments in India are also showing increased levels of interest in implementation of this technique to develop urban forests and thereby increase the green cover and native biodiversity in the city. However, there is absence of clear guidelines that need to be followed. In this situation, cities in India often times have to rely on experts to help them with the implementation of the technique. Provided below are the over-arching guidelines that city governments need to follow in order to develop any urban forest using the Miyawaki technique.

Step 1 – Soil Analysis and Soil Preparation

Understanding the texture of the soil helps to analyse the water holding capacity of the soil, the capacity of root perforation, water infiltration, and retention of nutrients by the soil.

This includes assessment of soil parameters like physical texture, organic carbon, nitrogen, soil pH, potassium, phosphorus and visible evidence of micro or macro fauna in the soil. This analysis helps to design natural methods for treatment of soil. This includes use of perforation material such as wheat, groundnut shells, corn husk, rice husk which will significantly improve perforation and help the roots to grow. Water retention materials like coco peat and sugarcane stock help the soil retain water and moisture. Addition of vermicompost, cow manure helps to improve the soil nutrient conditions. Addition of cultures of bacteria and mycorrhiza can also be decided based on the assessment results. Soils that are deficient in nitrogen would benefit immensely through Arbuscular Mycorrhizal Fungi (AMF) and nitrogen fixing bacteria like Rhizobium. AMF is available commercially and can even be cultured. Nitrogen fixing bacteria can be cultured and can also be added to the soil by planting nitrogen fixing leguminous plants.

Soil texture also needs to be studied. Loamy soils are the most preferred as they contain a good mix of sand, clay and organic matter and provide the ideal balance of water, nutrients as well as drainage, thereby supporting good plant growth.

At the end, it is essential to add a layer of mulch. This will protect and insulate the soil, thereby preventing excessive water loss due to evaporation. Some excellent options are dried grass, dried leaves, barley stalk, wheat stalk, rice straw, and corn stalk.

Step 2 – Determination of Native Species and Floral Composition through Quadrat Survey

This step involves developing a database of the floral diversity through a quadrat survey in a native forest in the same agro-climatic zone as the site where the Miyawaki forest is aimed to be developed. Through this survey, the potential natural vegetation can be determined. The same also needs to be validated using secondary information like the published flora of the region (in India, the Botanical Survey of India regularly updates the flora of different regions and the same should be referred to). The data (quantitative and qualitative), thus collected will help to develop the plant community composition that will be developed through the Miyawaki technique. The community composition should comprise of plants of all forms (trees, shrubs, herbs) in order to develop a natural forest. Species selection should be done in a manner that a mix of flowering, medicinal, timber, and fruiting species are chosen. While choosing the trees for the Miyawaki forest to be developed, emphasis should be given on selecting the 5 most dominant native trees (based on the results from the quadrat analysis). These trees will constitute around 50 percent of the floral diversity of the forest. The next abundant native species (based on the results from the quadrat analysis) will constitute 25-40 percent of the forest. The rest of the forest will be comprised of native species which have been found in the next level of abundance in the quadrat study.

Step 3 – Procurement of Saplings

This step involves finding nurseries which will provide good quality saplings of the desired species. It is important to make sure that planting materials match the quality standards defined and ensure no adulteration of any form has been done. Saplings from well-known private nurseries and nurseries maintained by the State Forest Department should be used. The ideal height for each sapling is 60-80 cm.

Step 4 – Preliminary Preparation for Plantation

Once the site for plantation/afforestation has been identified, it is necessary to procure all equipment and prepare for undertaking the plantation. This includes designing adequate water supply (pipeline/ overhead tank/borewell/tanker etc). The saplings will need to be watered daily for the first two years. Ideally space for site office, storing equipment, along with space to store the saplings and labourer's resting area needs to be identified. The site should also be accessible for trucks, earthmovers, tankers etc. In case the access is not there, the same needs to be constructed.

Step 5 – Undertaking Plantation

This is the most critical step for the successful establishment of a Miyawaki forest. The sub-steps that need to be followed are:

- In the plantation area, separate plantation bed area needs to be drawn out.
- The soil needs to be excavated for 3-4 feet.
- This excavated soil then needs to be mixed with the appropriate amounts of perforators, organic fertilizers and water retainers. The mixed soil should then be put back into the land. Care needs to be taken that the land does not get compressed at this stage and should be left aerated and loose.
- The levelled soil needs to be marked with chalk and pits (12"X12") should be dug at every 1.5-2 feet, in a triangular manner.
- The saplings should then be placed in these pits, taking care that saplings of the same species are not planted next to each other.
- After the sapling is planted, 4-5 feet bamboo sticks should be inserted in the soil, close to the sapling. This will help prevent the sapling from drooping or bending in the first few months.
- Finally, a 5-7-inch-thick layer of mulch should be added to the soil (a minimum of half kg of mulch per tree needs to be added).
- For the first time, the saplings must be watered for an hour to make sure the mulching and the soil settle down.
- Tree density of 3trees/m2 is ideal.

Step 6 – Maintenance and Monitoring

Site specific maintenance and monitoring needs to be undertaken for two years, post plantation.

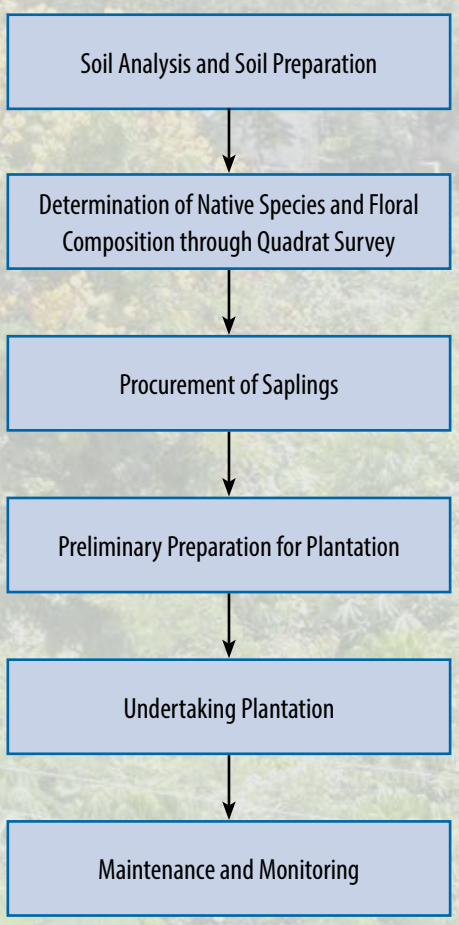

Figure 1: Steps to be followed for development of a Miyawaki forest

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