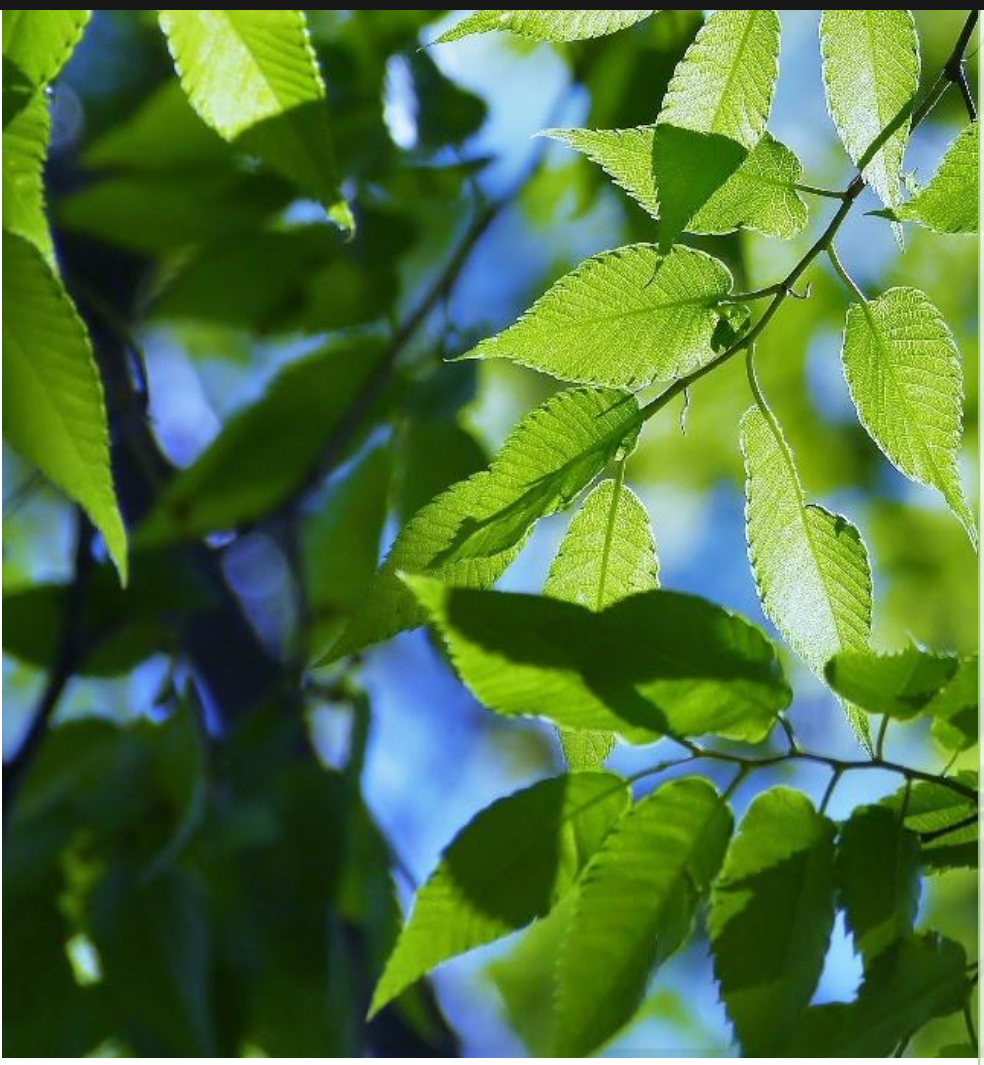
CRISIL

An S&P Global Company

CRISIL FOUNDATION - CARBON SEQUESTRATION STUDY REPORT 2021



PREPARED BY –

CENTRE FOR ENVIRONMENTAL RESEARCH AND EDUCATION

Document Name:	CRISIL Foundation – Carbon Sequestration Study Report 2021
Date of Publication	26th November 2021
Prepared By	Centre for Environmental Research and Education (CERE)
Contact details	S-11 Jamasji Apartments, Naushir Bharucha Road (Sleater Road), Grant Road (W), Mumbai 400007
Website	www.cere-india.org www.uap.cere-india.org

ABOUT CERE

Centre for Environmental Research and Education (CERE) is a non-profit organisation, working to promote environmental sustainability through education, research, awareness and advocacy. CERE has completed projects in both urban and rural India successfully, having worked closely with different government departments, educational institutions, multinational companies, and civil society organizations. A pioneer in the field of corporate sustainability and carbon management systems, CERE helps organizations map their carbon footprint, meet international reporting standards, implement low-cost carbon reductions strategies that ensure considerable financial savings and engage in staff awareness activities. CERE also undertakes CSR projects for corporate clients in the areas of biodiversity, water management and harvesting, renewable energy and environmental education.

DISCLAIMER

CERE has taken all reasonable care to ensure that the facts stated as a part of this report are true and accurate in all material aspects as at the date of preparation and as per the information and plantation data supplied by its plantation partners. CERE will ensure that the report remains secure and confidential and takes full responsibility for the same, unless and until CRISIL Foundation gives permission otherwise.

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

Objectives of the Project:

i. Geotagging of trees at each plantation site in the cities of Mumbai and Pune to determine survival rates and species diversity.
ii. Undertaking a study to determine the carbon sequestration potential of a standing plantation at every location within the two cities.
iii. Certifying the carbon sequestration potential of the afforestation drive undertaken by the CRISIL Foundation.

Methodology:

The project carried out the geotagging of 13,574 saplings at 10 different locations across the cities of Mumbai and Pune. Out of the ten sites, four had conventional plantations while the remaining six sites had Miyawaki plantations. The plantations were assessed through visual observations and through geotagging of the saplings. With the help of the data procured and the observations made during the geotagging process, the survival rate of the plantation was calculated. The methodology used for geotagging was based on the Memento Database application, which is an android app. The app captures the geographical coordinates (latitude and longitude), the name, and the image of the species tagged. Based on statistical analysis, the sample size was selected for all the locations and a certain number of saplings were geo-tagged covering the entire site and keeping in check all the species planted. Other management observations were also noted on the site, such as de-weeding, watering regime, security, grass clearing, and the overall maintenance of the site. The geotagging process was started on the 14th of August 2021 at Chaturshrungi plantation site, Pune, and ended on the 29th of October 2021 at the Sanjay Gandhi National Park plantation site in Mumbai. Post geotagging, the data was analysed by CERE researchers to calculate the carbon sequestration potential of all the plantations.

Results:

As a result of the Carbon Sequestration Study of CRISIL Foundation's plantations, a total of **13,574 trees were geotagged** at the 10 different locations across the cities of Mumbai and Pune in the state of Maharashtra. The potential carbon sequestration from these 10 plantation sites cumulatively would be **8646.29 MTCO$_2$** over the period of 15 years. Along with the geotagging, other observations were also taken during the site visits which helped in the calculations of survival rate and mortality rate and helped in understanding the overall health of the plantations.

2. INTRODUCTION

CRISIL Foundation

CRISIL is a global analytical company and India's foremost provider of ratings, data, research, analytics, and solutions. CRISIL Foundation is the Corporate Social Responsibility (CSR) branch of CRISIL and works for the welfare of socially and economically disadvantaged communities. It also works towards environment conservation through tree plantation and maintenance drives to increase the green cover, solar electrification, and sustainable waste management.

Carbon Sequestration through Afforestation

Carbon sequestration is a process by which CO_2 is either removed from the atmosphere or diverted from emission sources and stored in the ocean, terrestrial environments (vegetation, soils, and sediments), and geologic formations (1). Article 3.4 of the Kyoto protocol, identifies forests as large and long-lived sources of carbon storage and proper land and afforestation management systems can aid in mitigating the increase of atmospheric CO_2 through the process of carbon sequestration (2).

According to the International Energy Agency (IEA), India will be among the top three emitters of greenhouse gases in the world by 2030 (3). At the same time, the country is incredibly vulnerable to global warming and a recent World Bank report suggests that climate change could cost India 2.8 percent of GDP, and depress living standards of nearly half of its population by 2050 (4). There is thus a strong interest in stabilizing the atmospheric abundance of CO_2 and other GHGs to mitigate the risks of global climate change.

Trees can act as excellent carbon pools that capture and store atmospheric CO_2 through a natural process known as photosynthesis (5). The ability of trees to capture and store carbon varies from species to species and a healthy habitat of mixed species is likely to store a greater volume of carbon over the long term as it also promotes soil health and thus increases the amount of carbon stored in the soil as well.

Carbon Sequestration Study

CRISIL Foundation has planted a total of **39,680*** saplings through their plantation drives in the year 2019, 2020, and 2021. The plantation types vary from single mass plantations distributed over hillsides or villages to Miyawaki style dense forest, across different locations across the cities of Mumbai and Pune. The project aimed to conduct a tree audit and carry out the Carbon Sequestration Study of these plantations to determine the carbon sequestration potential of these plantation sites with the help of geotagging of the trees and calculating their survival rate. The study also helped to observe the maintenance and overall health of all the plantations. *(According to the species lists shared by the CRISIL Foundation and plantation partners, the total no. trees planted is 39,770, including extra trees planted during the afforestation drives)

3. METHODOLOGY

Project Design and Plan

The project was initiated with a designed course of action, which included the following phases:

1. Coordination with the plantation partners to get important information about the plantation.
2. Scheduling and conducting site visits for geotagging of a statistically calculated sample size of the trees.
3. Calculation of the carbon sequestration potential of the sites, depending on the data acquired during geotagging.
4. Issuing of carbon sequestration certificate to CRISIL Foundation for the afforestation drives.

Coordination with the Plantation Partners:

The plantation carried out by CRISIL Foundation during 2019, 2020, and 2021 in Mumbai and Pune was done with the help of five plantation partner NGOs:

i) Green Hills Group/ United Way of Mumbai
ii) Green Yatra
iii) Grow Trees
iv) International Association for Human Values (IAHV)
iv) Nature Forever Society (NFS)

CERE coordinated with all the above-mentioned plantation partners to acquire the essential data to understand the plantation and the sites. The data included:

- Species list and count of the saplings planted,
- Type of plantation (Conventional, Miyawaki)
- Photographs of the plantation
- Type of soil present at the site
- Sapling Distribution Pattern
- Topography of the region
- Water Supply System

The data was collected to develop a thorough understanding of the plantation site, before the site visits for geotagging could be conducted. An introductory webinar was held for all the plantation partners along with CRISIL Foundation, to help them understand how the whole process of geotagging will take place and what kind of coordination and cooperation would be required from their end. CERE's geotagging team also interacted with the partners during the webinar and answered their queries regarding the geotagging process.

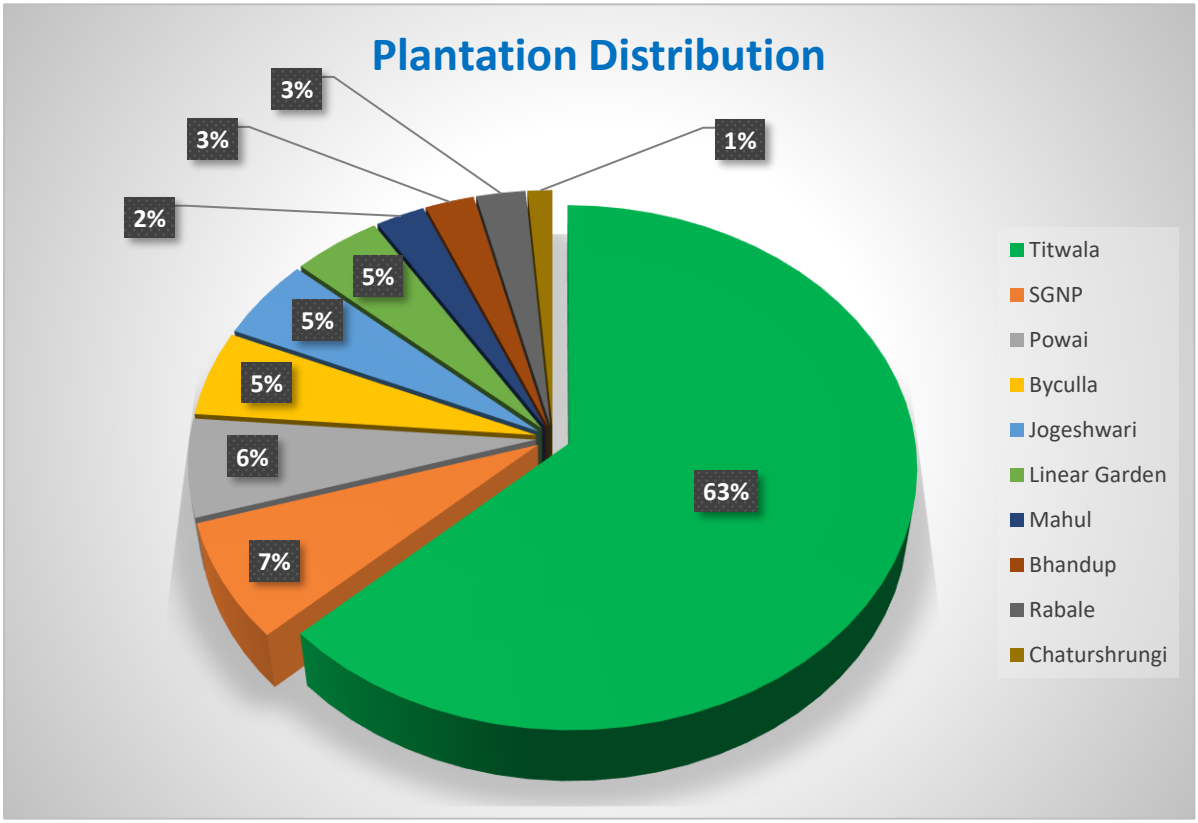
Plantation Locations:

The CRISIL Foundation planted a total of 39,680 saplings across Mumbai and Pune with the help of different plantation partners. The plantation drive was carried out across ten locations, namely:

- Titwala
- SGNP
- Powai
- Byculla
- Jogeshwari
- Linear Garden
- Mahul
- Bhandup
- Rabale
- Chaturshrungi

The chart given below displays the percentage-wise distribution of the plantation at each site:

Chart 1. Percentage-wise Plantation Distribution



Following is the table showing the no. of trees planted at each of the locations:

S. No.	City	Plantation Partner	Location	No. of Trees Planted
1.	Mumbai	Grow Trees	Rayta Village, Titwala	25,000
2.		Green Yatra	Police Dumping Ground, Mahul	1,000
3.			Water Filtration Plant, Bhandup	1,000
4.			CRWC, Jogeshwari	2,000
5.		International Association for Human Values (IAHV)	Tetavali Village, Rabale	1,000
6.		Nature Forever Society	Sanjay Gandhi National Park	2,880
7.			Ambrosia Garden, Powai	2,400
8.			Byculla Zoo	2,100
9.	Pune		Linear Garden	1,800
10.		Green Hills Group / United Way of Mumbai	Chaturshrungi Hills	500
Total				**39,680**

Table 1. No. of Trees Planted at each Plantation Site

Geotagging Process:

Geotagging is a process of identifying the physical location of a tree, by determining its geographical coordinates (latitude and longitude). The data is captured with the help of applications that work using the Global Positioning System (GPS) or satellite positioning. Geo-tagging helps in confirming the number of species planted at the site and also to calculate their carbon sequestration potential with accuracy. The geo-tagging team also clicks photographs, record the species name, and documents the overall health and growth of the plant. Documentation of the photograph and geotagged locations of the plant can help to locate the plantation in the future to assess its health and growth over time.

The geotagging exercise is, however, based on the satellite data, therefore, minor variability in the data is possible.

The number of trees that are finally geo-tagged by the team on-site is dependent on the following factors:

- List of tree species planted
- The survival rate of the plantation
- Photographs of the plantation
- Network and data availability at the plantation site
- Accessibility to the local plantation partner and the location
- Any unforeseen limitations at the site

The process is carried out using a software-based, android application called "Memento Database'. The GPS coordinates of the tree are stored in the software using the application. This data also helps to determine the species diversity present at the site and thus helps to calculate the carbon sequestration potential of the plantation.

The geotagging methodology depends on the size of the plantation. Since it is unfeasible to geotag 39,680 trees altogether, due to physical constraints, the sample size was determined for the number of trees to be geotagged at each plantation site using a scientific statistical method called "Simple Random Sampling". It is a standard, globally accepted method that helps to calculate a sample size that is representative of the overall population of trees present at the site.

The determination of the sample size is based on the following:

- If the number of trees planted is less than or equal to 100 in a location, 100% of the trees are geotagged.
- If the number of trees planted is between 100 – 500 in a location, 50% – 60% of the trees are geotagged.
- If the number of trees planted is more than 500 in a location, then a sample size is determined for geotagging, using the Simple Random Sampling method. The sample size represents the total number of trees planted at the location.

Depending on the sample size, the plantation site is divided into sections, and trees are randomly selected in each section for geotagging. The selection of trees is done in such a way that at least 10% of every species is geotagged and the overall plantation site is entirely accessed. During the geotagging, pictures and other information about the species are also collected. The species list and their numbers provided by the plantation partners are tallied with the trees found on the site during the overall count of the trees.

The following table shows the no. of trees geotagged at each of the 10 locations, based on the calculated sample size:

S. No.	City	Location	No. of Trees Planted	No. of Trees to be Geotagged	No. of Trees Geotagged
1.	Mumbai	Rayta Village, Titwala	25,000	8,000	8,392
2.		Police Dumping Ground, Mahul	1,000	500	180
3.		Water Filtration Plant, Bhandup	1,000	400	592
4.		CRWC, Jogeshwari	2,000	800	813
5.		Tetavali Village, Rabale	1,000	500	567
6.		Sanjay Gandhi National Park	2,880	920	-
7.		Ambrosia Garden, Powai	2,400	900	919
8.		Byculla Zoo	2,100	800	811
9.	Pune	Linear Garden	1,800	730	756
10.		Chaturshrungi Hills	500	500	544*
Total			**39,680**	**14,050**	**13,574**

Table 2. The total number of trees geotagged at each location

*328 trees are geotagged from 2019's plantation and extra 216 trees are geotagged from 2018's plantation at the Chaturshrungi site.

Data Analysis and Interpretations:

The data gathered during the geotagging process is evaluated to calculate the carbon sequestration value of each plantation site. The calculations are based on the total count of the trees, species distribution and diversity found on the site, and the survival rate of all the species. The survival rate was calculated by taking into consideration the total number of trees geotagged in a preselected area and an observed count of the entire plantation. Each plantation site was divided into sections and the geotagging of trees was done as per the decided sample size in a manner that the overall plantation area is covered while geotagging. Replantation was recommended at the sites where mortality was observed.

Other observations such as soil quality, irrigation techniques, presence of any diseases or infections on plants and trespassing on-site, etc. were also noted by the team.

4. SITE-WISE OBSERVATIONS

The site visits were conducted at the locations of Titwala, Mahul, Bhandup, Jogeshwari, Rabale, Sanjay Gandhi National Park, Powai, Byculla, Linear Garden, and Chatushrungi. The geotagging was carried out for the plantation of 39,680 trees across these locations. During the site visits, the observations were taken based on the species count, species diversity, soil type, water supply, de-weeding regime, security, and the overall health of the plants.

This section represents the site-wise observations and geotagging details of all the locations:

4.1. MUMBAI PLANTATION SITES

There are eight locations of CRISIL's plantations in Mumbai managed by four plantation partners. The sites at Mahul, Bhandup, and Jogeshwari are managed by an NGO called Green Yatra. The site at Rabale is managed by the International Association for Human Values (IAHV). The sites at SGNP, Powai, and Byculla are managed by Nature Forever Society (NFS). The Titwala plantation site is managed by Grow Trees NGO.

1. Police Dumping Ground, Mahul

2. Water Filtration Plant, Bhandup

3. CRWC, Jogeshwari

4. Tetavali village, Rabale

5. Ambrosia Garden, Powai

6.Byculla Zoo, Byculla

7. Sanjay Gandhi National Park

8. Rayta Village, Titwala

4.1.1. Police Dumping Ground, Mahul

The plantation site at Mahul is located at the Police dumping ground. The site is maintained by the plantation partner Green Yatra. A total of 1000 trees were planted at Mahul by the plantation partner. The no. of trees to be geotagged was 500. The geotagging at the site was conducted by CERE on the 2nd of September 2021. The total no. of surviving trees found at the site was 180 and the no. of trees geotagged by the CERE team was 180.

S. No.	Location	No. of Trees Planted	No. of Trees to be Geotagged	No. of Trees found at the site	No. of Trees Geotagged	No. of Physically Observed Trees (besides geotagging)	Survival Rate (%)
1.	Police Dumping Ground, Mahul	1,000	500	180	180	0	18%

Observations:

- The site is an enclosed compound and the plantation was done adjacent to the corners and the edge of the compound wall.
- As mentioned in the species list provided by the partner, there were 8 species of trees found on the site, namely, Coconut dwarf, Coconut Tall, Mango, Awla, Peru, Jamun, Chikoo, and Sitaphal.
- The average height of the saplings found was 8ft – 10 ft. A good distance of 5ft – 8ft was maintained between the saplings.

Fig. 1. Image of the Plantation Plot

- The soil type observed was garden soil with pebbles and some scrap on the site. Irrigation at the site is rainwater dependent.
- Continuous fencing was done, no trespassing or cattle grazing was observed at the site. Pest Infestation was seen on Coconut species.
- Water clogging was observed at one spot on the site. De-weeding was not done.

Fig. 2. Weed growth covering the Coconut tree

Fig. 3. Lethal Yellowing Disease was seen on the Cocos nucifera plant species

The following table shows the list of species found at the Mahul plantation site:

S. No.	Scientific Name	Common Name	No. of trees planted	No. of trees found on site
1.	*Annona squamosa*	Sitaphal	50	8
2.	*Cocos nucifera*	Coconut dwarf	250	30
3.	*Cocos nucifera*	Coconut tall	250	76
4.	*Mangifera indica*	Mango	100	30
5.	*Manilkara zapota*	Chikoo	100	15
6.	*Phyllanthus emblica*	Awla	50	9
7.	*Psidium guajava*	Peru	100	11
8.	*Syzygium cumini*	Jamun	100	1
Total			**1000**	**180**

Table 3: Species list and count of the plantation at Mahul site

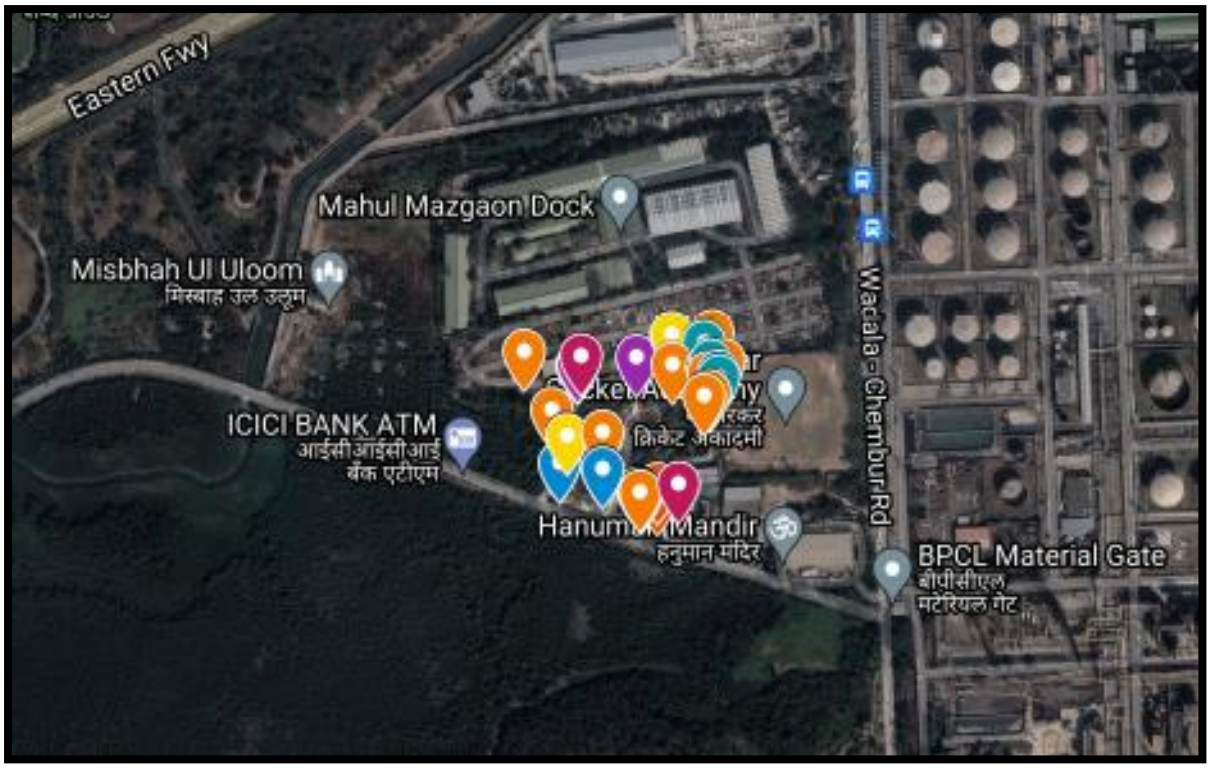


Fig. 4. Scatter map image Mahul plantation site*

*Different colors of the coordinates indicate the different species planted on the site.

Site-wise Recommendations:

- The site must be well managed in case of water clogging situations and proper drainage must be ensured to avoid it.
- Fungal Infections were also seen in many plant species. Carbendazim fungicide and Borax are recommended to be used both as curative and preventive for the control of diseases in plant species.
- *Cocos nucifera* was infected with yellowing Coconut disease. It is recommended to control this by removal of infected plants to reduce disease severity.
- Weed growth was observed around many plant species. Therefore, it is recommended that de-weeding should be done regularly on the site. Weeds should be removed from a minimum 1-meter area around plant species. This can be achieved by manual removal of weeds using a hoe while ensuring that no roots are left behind otherwise the weeds tend to grow back.
- The grass cover must be removed regularly using a grass cutting machine to avoid any chances of a possible fire at the site.
- It is recommended to ensure the proper removal of invasive plant species to avoid any damage to native plants at the site. Pruning of the entire species is recommended for the same.

4.1.2. Water Filtration Plant, Bhandup

The Bhandup plantation site is a garden area located next to the MCGM Inspection bungalow, near the Water Filtration Plant in the Bhandup complex. The site is owned by Bombay Municipal Corporation. The plantation at the site is done and managed by the plantation partner Green Yatra, who had planted a total of 1,000 trees through the Miyawaki technique (herbs and shrubs included). The no. of trees to be geotagged at the site was 400. CERE undertook the geotagging activity at the Bhandup site on the 2nd of September 2021. The no. of trees found at the site were 1,000 and the no. of trees geotagged were 592, out of which 3 trees were dead.

S. No.	Location	No. of Trees Planted	No. of Trees to be Geotagged	No. of Trees found at the site	No. of Trees Geotagged	No. of Physically Observed Trees (besides geotagging)	Survival Rate (%)
1	Water Filtration Plant, Bhandup	1,000	400	1,000	592	418	100%

The species list shared by the plantation partner for the Bhandup site collectively had 3,562 trees, out of which CERE had to consider 1,000 trees for CRISIL's plantation. An area on site was shown to the geotagging team by the plantation partner, where the team geotagged 592 trees & physically counted 418 trees. A total of 1,007 alive trees were found in that plot, out of which 1,000 are considered. The plantation area selection was done with mutual understanding between CRISIL and the plantation partner.

Fig. 5. Image of the plantation plot

Observations:

- The area under the plantation is around 500 sq. m., as per the information given by the plantation partner. The plantation is done in a single, rectangular plot. The surroundings of the plot have a forest area and the Vihar lake in close vicinity, therefore the site is rich in biodiversity.
- The soil type at the site was loamy/ clayey. The plantation pits made for the trees were deep enough. Tree guards were not present and not required at the site, while support sticks were used for small plants.
- The average height of sapling was between 15ft – 18ft (dependent on the herb, shrub, or tree planted). The distance between the saplings was 1.5ft – 2ft.
- Irrigation at the site is done by drenching irrigation methods using pipes and sprinkler pipes. Water clogging was observed in some low-lying areas and along with some fungal infections in those areas.

Fig. 6. Natural fencing

Fig. 7. Image of plants with support stick.

Fig. 8. Dried plant

Fig. 9. Leaf spot and blight disease on Pongamia pinnata species

- The site is fenced by a continuous brick wall. No signs of trespassing or cattle grazing were observed. Some monkeys were seen damaging the plants.
- 42 species out of the 46 species mentioned in the species list provided by the partner were found on the site. A new species 'Umbar' was also found on the site. The four species that were missing were Cluster Fig, Raktachandan, IBhend, and Rohida. The site had a very good survival rate.

Species List:

S. No.	Scientific Name	Common Name	No. of trees planted	No. of trees found on site
1.	*Aegle marmelos*	Bel	71	26
2.	*Alstonia scholaris*	Saptaparni	71	47
3.	*Annona squamosa*	Sitaphal	36	1
4.	*Artocarpus heterophyllus*	Jackfruit	71	18
5.	*Azadirachta indica*	Neem	249	60
6.	*Bauhinia variegata*	Kachnar	178	116
7.	*Bombax ceiba*	Sawar	107	3
8.	*Butea monosperma*	Palas	99	12
9.	*Cassia fistula*	Amaltas	178	66
10.	*Cestrum nocturnum*	*Ratrani*	36	1
11.	*Cinnamomum tamala*	Tejpatta	14	2
12.	*Citrus limon*	Lemon	18	12
13.	*Cochlospermum religiosum*	Yellow slik cotton	36	1
14.	*Dalbergia sissoo*	Shisam	18	11
15.	*Ficus glomerata*	Cluster Fig	249	0
16.	*Ficus racemosa*	Umbar	0	72
17.	*Garcinia indica*	*Kokam*	14	1
18.	*Gardenia jasminoides*	Ananta	14	10
19.	*Hibiscus syriacus*	Hibiscus	36	9
20.	*Justicia adathoda*	Adulsa	50	24
21.	*Lagerstroemia speciosa*	Jarul	178	7

22.	*Madhuca longifolia*	*Mahua*	71	1
23.	*Magnolia champaca*	Sonchafa	142	3
24.	*Mangifera indica*	Mango	11	6
25.	*Mimusops elengi*	Bakul	82	26
26.	*Moringa oleifera*	Drumstick	14	1
27.	*Murraya koenigii*	Curry Leaf Plant	28	7
28.	*Murraya paniculata*	Kunti	18	2
29.	*Neolamarckia cadamba*	kadamb	249	19
30.	*Nerium oleander*	Kaner	36	16
31.	*Nyctanthes arbor-tristis*	Parijatak	18	1
32.	*Phyllanthus emblica*	Awla	36	39
33.	*Pongamia pinnata*	Karanj	107	94
34.	*Pterocarpus santalinus*	Raktchandan	71	0
35.	*Psidium guajava*	Peru	24	25
36.	*Sapindus emarginatus*	*Ritha*	18	1
37.	*Saraca asoca*	*Sita Ashok*	71	3
38.	*Schleichera oleosa*	Kusum	18	7
39.	*Swietenia mahagoni*	Mohagany	36	48
40.	*Syzygium cumini*	Jamun	249	47
41.	*Tabernaemontana divaricata*	Chandani	36	13
42.	*Tecomella undulata*	Tecomella	25	0
43.	*Tectona grandis*	Saag	142	57
44.	*Terminalia arjuna*	Arjun	36	5
45.	*Terminalia bellirica*	Beheda	36	23
46.	*Terminalia catappa*	Badam	249	57
47.	*Thespesia populnea*	Bhend	16	0
Total			**3562**	**1000**

Table 4: Species list and count of the plantation at the Bhandup site

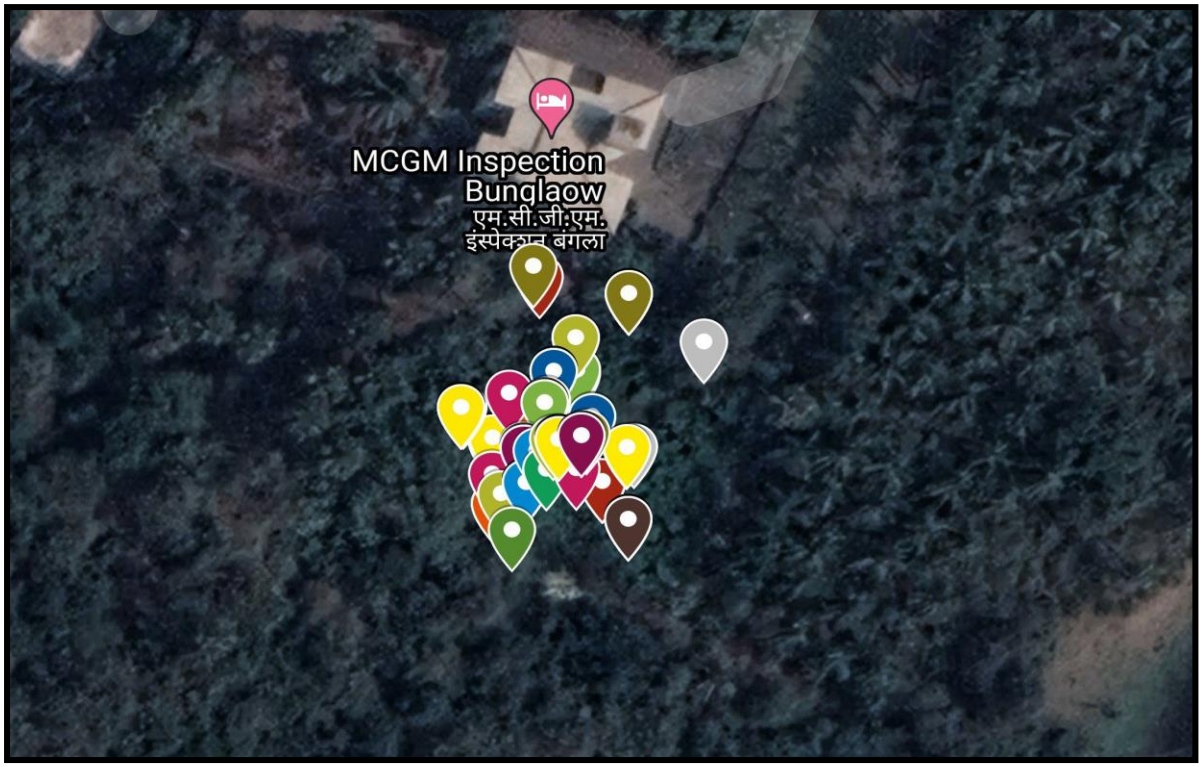


Fig. 10. Scatter map image of the Bhandup plantation site

Site-wise Recommendations:

- The site SPOC should be well aware of the plantations done on-site and other details such as irrigation timings.
- Proper handling of grass cutting machines should be done to avoid any kind of physical damage to the plants while cutting grasses.
- It is recommended to ensure few protective measures at the site because there is a possibility of damage to the plants by Monkeys and Langurs present at the site.
- Fungal Infections were also seen in many plant species. Carbendazim fungicide is recommended to be used both as curative and preventive for the control of diseases in plant species.
- Foliar spray of Bavistin fungicidal solution (0.1%) is recommended to treat the leaf spot disease on *Pongamia pinnata* species.

4.1.3. CRWC, Jogeshwari

The plantation site was located on a roadside near the Central Railside Warehouse Company (CRWC) compound in Jogeshwari. The site is managed by the plantation partner Green yatra who had planted a total of 2,000 saplings of 31 different species at the site. A total of 800 trees were to be geotagged at the site. The geotagging process was conducted on the 3rd and 6th of September 2021 by CERE.

S. No.	Location	No. of Trees Planted	No. of Trees to be Geotagged	No. of Trees found at the site	No. of Trees Geotagged	No. of Physically Observed Trees (besides geotagging)	Survival Rate (%)
1.	CRWC, Jogeshwari	2,000	800	1,256*	813	129	62.80%

The total number of trees geotagged in the accessible area is 813 and physically counted is 129, totaling to 942 trees. Certain internal patches of the plantation area were inaccessible for geotagging/ physical counting due to excessive growth of weeds, climbers, and waste dumps. Therefore, to determine the number of trees present in the inaccessible area, the following assumptions have been taken:

- based on the judgment of the ground Geotagging team, the inaccessible area was approximately 25% of the total plantation area
- the average density (considering equal spacing of the trees) in the geotagging areas (where trees have been geotagged and/or physically counted) is the same as that of inaccessible areas.

Considering the above two assumptions, the total number of trees possibly present in the inaccessible areas is derived to be 314. Therefore, the total number of trees present on the plantation site including the trees in inaccessible areas stands at 1256.*

Fig. 11. Team members accessing the site

Fig. 12. Board at the site displaying funder's name

Observations:

- The plantation area was approximately 3000 - 3500 sq. m according to the plantation partner. It was a continuous plantation in a single stretch. However, there was encroachment towards the opposite end of the site.
- The soil type found at the site was fertile garden soil, but the presence of a lot of filth and dumped waste was observed at the site. Tree guards were not used and support sticks were present at some places but most were damaged. The plantation pits were deep enough.
- The plantation was done through the Miyawaki technique. The average height of the saplings was ranging from 2 ft – 15 ft, based on different plant species and site conditions. An approximate distance of 1.5ft – 4 ft was maintained between individual saplings.
- The irrigation at the site was done using water tankers (as per the information provided by the SPOC during the preliminary site visit). Water clogging was seen in some corners due to rain.
- No fence was present at the boundaries of the site and trespassing by people was observed. However, there were no signs of cattle grazing.
- No de-weeding was done at the site. Damage due to invasive climbers like *Dioscorea bulbifera* and *Cuscuta* species was observed. Human and Animal faeces, broken trees, and damaged plant parts due to the dumping of construction waste were observed at the site. Trees planted towards the roadside were fallen and broken due to vehicular activities.
- Due to poor site conditions and the presence of dense climber cover, some part of the site was inaccessible to the team.

Fig. 13. Image of the plantation plot

Fig. 14. Image showing the inaccessible area at the site

Fig. 15. Construction waste dumped in and around the site

Fig. 16. Broken trees due to human activities near the site (vehicle assumed)

Fig. 17. Image showing human waste/garbage and filth on the site

Fig. 18. Image showing invasive climbers like Dioscorea bulbifera and Cuscuta species.

Species List:

S. No.	Scientific Name	Common Name	No. of trees planted	No. of trees found on site
1.	*Aegle marmelos*	Bel	60	2
2.	*Allamanda cathartica*	Golden Trumpet	100	0
3.	*Alstonia scholaris*	Saptaparni	90	50
4.	*Azadirachta indica*	Neem	90	36
5.	*Bambusa vulgaris*	Bamboo	75	12
6.	*Bauhinia racemosa*	Apta	80	31
7.	*Bauhinia variegata*	Kachnar	90	69
8.	*Bixa orellana*	Lipstick tree	0	65
9.	*Bougainvillea spectabilis*	Bogainvillea	70	0
10.	*Cascabela thevetia*	Yellow Oleander/ Peeli Kaner	80	61
11.	*Cassia fistula*	Amaltas	0	20
12.	*Cinnamomum tamala*	Bay leaf/ Tej patta	60	16
13.	*Citrus limon*	Nimbu	20	31
14.	*Dalbergia sissoo*	Sheesham	0	1
15.	*Dalbergia latifolia*	Indian Rosewood	0	1
16.	*Ficus racemosa*	Cluster Fig/ Goolar	20	20
17.	*Garcinia indica*	Kokum	80	0
18.	*Gmelina arborea*	White Teak/ Shivan	0	3
19.	*Hibiscus rosa-sinensis*	Chinese Hibiscus/ Gudhal	20	10
20.	*Lagerstroemia indica*	Crape Myrtle	60	82
21.	*Madhuca longifolia*	Mahua	75	13
22.	*Manilkara hexandra*	Khirni	75	19
23.	*Manilkara zapota*	Chikoo	70	0

24.	*Mimusops elengi*	Bakul	68	19
25.	*Moringa oleifera*	Drumstick tree	90	17
26.	*Neolamarckia cadamba*	Kadamb	0	4
27.	*Phyllanthus emblica*	Awla	75	42
28.	*Pongamia pinnata*	Karanj	60	94
29.	*Psidium guajava*	Peru	70	5
30.	*Ricinus communis*	Castor Oil Plant	0	1
31.	*Sapindus mukorossi*	Reetha	68	7
32.	*Saraca asoca*	Sita Ashok	64	42
33.	*Schleichera oleosa*	Kusum	70	4
34.	*Swietenia macrophylla*	Mahogany	90	39
35.	*Syzygium cumini*	Jamun	70	55
36.	*Syzygium samarangense*	Java Apple	60	0
37.	*Tamarindus indica*	Tamarind/ Imli	0	11
38.	*Terminalia bellirica*	Baheda	60	42
39.	*Terminalia catappa*	Indian Almond	0	2
40.	*Thespesia populnea*	Portia tree	20	16
Total			**2080**	**942***

Table 5. Species list and count of the plantation at the Jogeshwari site

*Species-wise inventory was prepared for 942 trees at this site since 25% area wasn't accessible as mentioned in the assumptions, this data for 942 trees is extrapolated for calculating the carbon sequestration for 1,256 trees.

A total of 26 species out of 31 mentioned in the species list provided by the plantation partner, were found on the site. The five missing species were Golden Trumpet, Bougainvillea, Kokum, Chikoo, and Java Apple.

There were also nine new species found on the site, namely: Indian Almond, Tamarind, Castor Oil Plant, Kadamb, White Teak, Indian Rosewood, Shisham, Amaltas and Lipstick tree. The total species of trees found on site was 35.

Fig. 19. Scatter map image of the geotagged coordinates at Jogeshwari site

Site-wise Recommendations:

- It is recommended to ensure proper management of the site and prohibit activities that damage the plantation, such as dumping construction waste. Proper fencing must be done to ensure safety from trespassers.
- It is also recommended to ensure that all areas of the site are accessible for survey purposes. Areas having filth and human waste should not be considered hygienic for survey purposes.
- It is recommended to ensure cleanliness at the site to avoid soil deterioration and plant damage.
- It is recommended to put support sticks while the plantation to avoid plant damage.
- Fungal Infections were also seen in many plant species. Carbendazim fungicide and Borax are recommended to be used both as curative and preventive for the control of diseases in plant species.
- Foliar spray of Bavistin fungicidal solution (0.1%) is recommended to treat the leaf spot disease on *Pongamia pinnata* species.

4.1.4. Tetavali village, Rabale

The plantation site at Rabale is located on a hilly slope at Tetavali village. The land is owned by the forest department and the plantation is maintained by the plantation partner International Association of Human Value (IAHV), in collaboration with their implementation partner, Hariyali Foundation. IAHV had planted a total of 1,000 saplings of 46 different species at the site. The no. of trees to be geotagged was 500. CERE carried out the geotagging activity at the Rabale site on the 25th of August 2021. The total trees found on the site were 1000, while the no. of trees geotagged was 567.

S. No.	Location	No. of Trees Planted	No. of Trees to be Geotagged	No. of Trees found at the site	No. of Trees Geotagged	No. of Physically Observed Trees (besides geotagging)	Survival Rate (%)
1.	Tetavali, Rabale	1,000	500	1,000	567	580	100%

The species-wise count for the site was not available with the plantation partner. Therefore, in agreement with CRISIL, a plantation area with approximately 1500 trees was shown to CERE's geotagging team. It was decided that out of this plantation, 1,000 trees are to be considered as CRISIL's plantation. Accordingly, an inventory of 1,147 trees was created and the data for the extra 147 trees were adjusted manually to make it up to 1,000 trees. Hence, there is 100% survival of the plantation at the site, considering extra trees present.

Fig. 20. Image of the plantation plot

Observations:

- The total area of the plantation was approximately 10,110 sq. m as per the information provided by the plantation partner. The area covered by the geotagging team during exercise was approximately around 2,800 to 3,000 sq. m. for 1000 trees. The trees were planted in a single plot on a hilly slope. The site was located near Hariyali and TTC Industrial area and surrounded by forest area. Hariyali is the nature conserved place in Navi Mumbai.
- The site had sandy soil. Support sticks were used for the small saplings and plantation pits were deep enough. Tree guards were not used at the site, also the stems of a few trees were observed to be damaged due to the grass cutting machine.
- It was a mass plantation. The saplings had attained a height between 8ft – 10ft. A good distance of 5ft – 8ft was maintained between individual saplings and pruning was well managed.
- The plantation was irrigated through drip irrigation technique and no water clogging was observed at the site.
- There was continuous fencing done at the site. No signs of cattle grazing were observed at the site, however, trespassing by locals was observed.
- 46 out of 51 species of plants mentioned in the list provided by the partner were found at the site. The plantation partner did not have the counts of the tree species planted. The missing species included Parijat, Peru, Muchkund, Shankasur, and Tuti. De-weeding was done at the site, but not completely. Three new species were also found at the site, namely: Shivan, Arjun, and Indian Cork Tree.
- *Grevillea robusta* (Silver Oak) and *Syzygium cumini* (Jamun) and *Mangifera indica* (Mango) species were found in abundance.

Fig. 21. Geotagging team working at the site

Fig. 22. Image showing weed growth around a plant

Fig. 23. Board placed at the site displaying funder's name

Fig. 24. Image showing newly planted sapling (Alstonia scholaris - Saptparni) with support stick

Fig. 25. Termite infestation on Tamarindus Indica (Chinch)

Species ist of the trees present in Crisil's plantation plot:

S. No.	Scientific Name	Common Name	No. of Trees Found on site
1.	*Acacia catechu*	Khair	1
2.	*Adenanthera pavonina*	Ratangunj	1
3.	*Aegle marmelos*	Bel	2
4.	*Albizia lebbeck*	Shirish	19
5.	*Alstonia scholaris*	Saptaparni	67
6.	*Anacardium occidentale*	Cashew	3
7.	*Annona squamosa*	Sitaphal	1
8.	*Artocarpus heterophyllus*	Phanas	4
9.	*Azadirachta indica*	Neem	54
10.	*Bambusa bambos*	Bamboo	5
11.	*Bauhinia racemosa*	Apta	1
12.	*Bauhinia variegata*	Kanchan	35
13.	*Bombax ceiba*	Katesawar	1
14.	*Carissa carandas*	Karvand	1
15.	*Cassia fistula*	Bahava	39
16.	*Ceiba pentandra*	Kapok	4
17.	*Citrus limon*	Nimbu	1
18.	*Cocos nucifera*	Palm	4
19.	*Couroupita guianensis*	Cannon Ball Tree	1
20.	*Dalbergia sissoo*	Shisam	4
21.	*Delonix regia*	Gulmohar	27
22.	*Ficus benghalensis*	Banyan tree	29
23.	*Ficus racemosa*	Goolar	3
24.	*Ficus religiosa*	Peepal	23
25.	*Gmelina arborea*	Shivan	2

26.	*Grevillea robusta*	Silver oak	156
27.	*Lagerstroemia speciosa*	Jarul	16
28.	*Mangifera indica*	Mango	103
29.	*Mimusops elengi*	Bakul	15
30.	*Millingtonia hortensis*	Indian Cork Tree	1
31.	*Morinda citrifolia*	Bartondi	2
32.	*Neolamarckia cadamba*	Kadamb	6
33.	*Oroxylum indicum*	Tetu	1
34.	*Phyllanthus emblica*	Awla	1
35.	*Pithecellobium dulce*	Vilayti chich	5
36.	*Pongamia pinnata*	Karanj	55
37.	*Putranjiva roxburghii*	Putrajniva	1
38.	*Saraca asoca*	Sita Ashoka	2
39.	*Schleichera oleosa*	Kusum	2
40.	*Sterculia foetida*	Junglee badam	7
41.	*Swietenia mahagoni*	Mahogany	6
42.	*Syzygium cumini*	Jamun	144
43.	*Tamarindus indica*	Chinch	104
44.	*Tectona grandis*	Sag	26
45.	*Terminalia arjuna*	Arjun	1
46.	*Terminalia bellirica*	Beheda	7
47.	*Terminalia catappa*	Badam	1
48.	*Vitex negundo*	Nirgudi	5
49.	*Ziziphus jujuba*	Bor	1
Total			**1,000**

Table 6. Species list and count[1] of the plantation at the Jogeshwari site

[1] The above species list is the actual representation of the species present in Crisil's plantation patch.

Fig. 26. Scatter map image of the geotagged coordinates at Rabale site

Site-wise Recommendations:

- Proper handling of grass cutting machines should be done to avoid any kind of physical damage to the plants while cutting grasses.
- Termite Infestation was observed in the tree trunks (Fig. 25). It is important to take certain steps when termite infestation is observed in one of the trees. The infected wood should be pruned away or burnt so that the infection doesn't spread away. Then, Boric acid powder can be used to remove termites from infected plant species.
- Fungal Infections were also seen in many plant species. Carbendazim fungicide and Borax are recommended to be used both as curative and preventive for the control of diseases in plant species.
- Weed growth was observed around a few plant species (Fig.22.). Complete de-weeding should be done regularly on the site. Weeds should be removed from a minimum 1-meter area surrounded by plant species.
- It is recommended to avoid planting non-native plant species such as *Delonix regia* (Gulmohar) in future plantations.

4.1.5. Ambrosia Garden, Powai

The plantation at Ambrosia Garden was located at the Hiranandani Complex in Powai. It is maintained by the plantation partner Nature Forever Society. The site is owned by the Municipal Corporation of Greater Mumbai (MCGM). 2,400 trees of 63 different species were planted by the partner through the Miyawaki technique at the site. 900 trees were to be geotagged at the site. The geotagging activity was carried out at the site by CERE on the 4th of September 2021. The no. of trees found at the site was 1,122, out of which 919 trees were geotagged.

On request of the plantation partner, a recount along with the physical tagging was done at the Powai plantation site on the 5th of October 2021. The trees were physically tagged by the NFS team and a total of 1,546 trees are to be considered present at the site*. The carbon sequestration potential of the plantation is calculated based on the species details acquired for 1,122 trees during the primary geo-tagging exercise. Also, an average of carbon sequestration potential is calculated for the later found 424 trees. Both the values calculated are combined to get the overall carbon sequestration potential of this site.

S. No.	Location	No. of Trees Planted	No. of Trees to be Geotagged	No. of Trees found at the site	No. of Trees Geotagged	No. of Physically Observed Trees (besides geotagging)	Survival Rate (%)
1.	Ambrosia Garden, Powai	2,400	900	1,546*	919	203	64.42%

Fig. 27. Image of the plantation plot

Observations:

- The area under the plantation was said to be approximately 2500-3000 sq. m according to the plantation partner. The plantation was done in a single plot. It was surrounded by an open garden plot with landscapes.
- The soil type found at the site was loamy and clayey. The plantation pits were deep enough. Tree guards and support sticks were not present and were not needed.
- The average height of the saplings was 8 ft – 10 ft (also depends on herb, shrub, or tree species planted). Approximately 1ft – 1.5ft distance was maintained between individual saplings. Stratification was good and well-planned. De-weeding was done at the site and the dense canopy had helped to reduce the grass growth. The site was rich in biodiversity.
- Saplings were irrigated by the drenching irrigation method. Irrigation was also done using Sprinkling pipes. Water clogging was not observed; however, water was seen to be temporarily collected in the low-lying areas.
- Continuous garden wall fencing was there on the boundaries of the plot as well as the presence of security guards from BMC was seen. Trespassing was not seen on the site and no signs of cattle grazing were observed.
- A total of 59 different plant species were observed and geotagged at the site. All the planted species were native. Five of the species out of 63 mentioned in the partner's list were not found on site. These include the Red Cutch tree, Indian Thorny Bamboo, Mahua, Tetu, and Headache tree. Six plants of a new species 'Raktachandan' were identified and geotagged at the site.
- Small shrubs didn't seem to survive well due to the dense canopy. Prominent damage and death were seen in many plants due to fungal infestations leading to rotting. Water clogging at some parts of the plot led to damage and fungal infections in a few plants which were affected.

Fig. 28. Water clogging observed on site

Fig. 29. Water pipes for irrigation

Fig. 30. A geotagger assessing the plantation

Fig. 31. Physical tagging of the plants

Fig. 32. The Geotagging team, the SPOC from NFS and the sponsor's representative present at the site during first visit to the site

Species List:

The following is the species list of the 1,122 trees found by the CERE team during the geotagging process.

S. No.	Scientific Name	Common Name	No. of Trees Planted	No. of Trees found on site
1.	*Acacia chundra*	Red Cutch Tree	40	0
2.	*Acacia ferruginea*	Safed Khair	40	21
3.	*Acacia nilotica*	Babul	50	3
4.	*Aegle marmelos*	Bel	40	10
5.	*Albizia lebbeck*	Shirish	50	12
6.	*Albizia procera*	Safed Shirish	40	6
7.	*Alstonia scholaris*	Saptaparni	50	49
8.	*Aphanamixis polystachya*	Rakt Rohida	20	12
9.	*Artocarpus heterophyllus*	Jackfruit	50	25
10.	*Azadirachta indica*	Neem	50	19
11.	*Bambusa bambos*	Indian Thorny Bamboo	20	0
12.	*Bauhinia acuminata*	Safed Kanchan	50	12
13.	*Barringtonia acutangula*	Samudraphal	45	6
14.	*Bauhinia purpurea*	Purple kanchan	50	11
15.	*Bauhinia racemosa*	Apta	30	7
16.	*Bauhinia variegata*	Kanchan	50	44
17.	*Bombax ceiba*	Sawar	40	2
18.	*Bombax insigne*	Dev sawar	50	6
19.	*Butea monosperma*	Palash	40	17
20.	*Careya arborea*	Kumbhi	50	32
21.	*Carissa spinarum*	Karvand	30	20
22.	*Cochlospermum religiosum*	Yellow Silk Cotton	15	2
23.	*Cordia dichotoma*	Bhokar	30	20

24.	*Dalbergia latifolia*	Kala shisam	20	18
25.	*Dalbergia sissoo*	Shisam	50	37
26.	*Dendrocalamus strictus*	Hard Bamboo/Bans	25	50
27.	*Erythrina stricta*	Raan Pangara	50	18
28.	*Erythrina variegata*	Pangara	10	29
29.	*Ficus benghalensis*	Vad	50	50
30.	*Ficus racemosa*	Umbar	50	31
31.	*Ficus religiosa*	Peepal	60	31
32.	*Ficus virens*	Pilkhan, Amba Payar	25	5
33.	*Gmelina arborea*	Shivan	50	18
34.	*Holarrhena pubescens*	Pandhra kuda	20	5
35.	*Holoptelea integrifolia*	Papdi, Vaval	40	13
36.	*Lagerstroemia speciosa*	Jarul	60	12
37.	*Lawsonia inermis*	Mehandi	20	6
38.	*Limonia acidissima*	Kaitha	35	13
39.	*Macaranga peltata*	Chanda	30	10
40.	*Madhuca longifolia* var. *latifolia*	Indian Butter Tree	50	0
41.	*Magnolia champaca*	Sonchafa	40	2
42.	*Melia azedarach*	Bakan neem	40	10
43.	*Millingtonia hortensis*	Indian Cork Tree	40	28
44.	*Mimusops elengi*	Bakul	55	37
45.	*Nyctanthes arbor-tristis*	Parijatak	40	5
46.	*Oroxylum indicum*	Indian Trumpet Flower	40	0
47.	*Phyllanthus emblica*	Awla	30	18
48.	*Polyalthia longifolia*	False Ashoka	40	22
49.	*Pongamia pinnata*	Karanj	40	35
50.	*Premna serratifolia*	Headache Tree	20	0

51.	*Pterocarpus santalinus*	Raktchandan	0	6
52.	*Pterygota alata*	Buddha naral	20	20
53.	*Sapindus mukorossi*	Ritha	20	14
54.	*Senna siamea*	Kashid	40	30
55.	*Senna surattensis*	Motha Tarvad	50	21
56.	*Sterculia foetida*	Junglee Badam	50	38
57.	*Syzygium cumini*	Jamun	40	33
58.	*Syzygium salicifolium*	Pan Jambhul	30	13
59.	*Tamarindus indica*	Chinch	30	30
60.	*Terminalia arjuna*	Arjun	30	16
61.	*Terminalia bellirica*	Beheda	30	17
62.	*Terminalia catappa*	Badam	30	29
63.	*Vitex negundo*	Nirgudi	30	15
64.	*Wrightia tinctoria*	Kala kuda	40	1
Total			**2,400**	**1,122**

Table 7. Species list and count of the plantation at Powai site

Site-wise Recommendations:

- The site must be well managed in case of water clogging situations and proper drainage must be ensured to avoid it.
- Proper handling of grass cutting machines should be done to avoid any kind of physical damage to the plants while cutting grasses.
- Fungal Infections were seen in many plant species. Carbendazim fungicide and Borax are recommended to be used both as curative and preventive for the control of diseases in plant species.
- Gall disease was seen on *Pongamia pinnata* species. Galls can be controlled by manually removing do foliage and destruction by burning. It is recommended to control the spreading of disease by spraying 1% monocrotophos and dimethoate insecticides on a healthy plant.

Fig. 33. Scatter map image of the geotagged coordinates at Powai site

4.1.6. Byculla Zoo

The plantation site is located beside the Tiger enclosure at the Byculla Zoo in Mumbai. The site belongs to the Byculla Zoo Authority and the Municipal Corporation of Greater Mumbai. The site is managed by the plantation partner Nature Forever Society, who had planted 2,100 saplings at the site through the Miyawaki technique. The sample size to be geotagged at the site was 900 trees. The geotagging exercise was carried out at the plantation site on the 7th of September 2021. The number of trees found on site was 954 and CERE team geotagged a total of 811 trees.

On 30th October 2021, physical tagging and a recount were conducted at the site at the request of the plantation partner. The number of trees found surviving on the ground is 1,197, considering the very young saplings ranging from just 6 inches to 1 foot as well.

S. No.	Location	No. of Trees Planted	No. of Trees to be Geotagged	No. of Trees found at the site	No. of Trees Geotagged	No. of Physically Observed Trees (besides geotagging)	Survival Rate (%)
1.	Byculla Zoo	2,100	800	1,197	811	386	57%

Observations:

- The site is a garden land, created in a semi-circular shape. The plantation is done on a single plot, covering an area of 325 sq. m. according to the information provided by the plantation partner.

Fig. 34. Image of the plantation site

- The height of the trees was observed to be in between the range of 6 inches to 40 ft. An approximate distance of 1ft – 1.5 ft was maintained between individual saplings, and the plantation pits were observed to be deep enough.
- The site has fertile, garden soil. Support sticks were not present with the saplings. Some of the saplings required support sticks. Drench irrigation was used to water the plants through pipes. No water clogging was observed.
- A continuous fence is present around the plantation site. Trespassing was observed during both the visits, however, no destruction was observed due to that. No signs of cattle grazing were observed.
- Pest infestation was observed in *Pongamia pinnata (*Karanj), *Bauhinia variegate (*Kanchan), *Cassia fistula (*Bahava), *Alstonia scholaris* (Saptaparni*) and Ziziphus rugosa (*Wild jujube) plants. Some plants of *Erythrina variegata* (Pangara) and plants with a corky bark showed fungal infections.
- Some damage was observed due to the falling of branches from old trees, while a few dried trees were observed.

Fig. 35. NFS Team members carrying out the physical tagging

Fig. 36. Board displaying funder's name at the site

Fig. 37. A Geotagger and the SPOC from NFS observing the infected plant of Karanj

Fig. 38. Image showing lack of support sticks with the plants on site

Species List:

S. No.	Scientific Name	Common Name	No. of Trees Planted	No. of Trees found on site
1.	*Acacia catechu*	Khair	35	19
2.	*Acacia ferruginea*	Safed Khair	35	11
3.	*Acacia nilotica*	Babool	15	0
4.	*Adenanthera pavonina*	Thorla Gunj	25	21
5.	*Aegle marmelos*	Bel	30	25
6.	*Albizia lebbeck*	Siris	35	14
7.	*Albizia odoratissima*	Black Siris	30	13
8.	*Albizia procera*	White Siris	30	16
9.	*Alstonia scholaris*	Saptaparni	30	37
10.	*Artocarpus heterophyllus*	Phanas	25	13
11.	*Azadirachta indica*	Neem	0	3
12.	*Bambusa bambos*	Indian Thorny Bamboo	25	18
13.	*Bauhinia acuminata*	Safed Kanchan	25	19
14.	*Bauhinia purpurea*	Kanchan	25	8
15.	*Bauhinia variegata*	Kachnar	20	11
16.	*Bombax ceiba*	Savar	35	15
17.	*Bombax insigne*	Dev Savar	35	10
18.	*Barringtonia acutangula*	Samudraphal	0	2
19.	*Butea monosperma*	Palash	30	28
20.	*Caesalpinia bonduc*	Sagargota	25	12
21.	*Caesalpinia decapetala*	Chillar	35	13
22.	*Careya arborea*	Kumbhi	20	11
23.	*Carissa spinarum*	Karvand	35	19
24.	*Cassia fistula*	Bahava	30	28

25.	*Cordia dichotoma*	Bhokar	15	15
26.	*Dalbergia lanceolaria*	Dandoos	20	0
27.	*Dalbergia sissoo*	Shisham	30	23
28.	*Dendrocalamus strictus*	Manvel Baans	25	31
29.	*Dillenia indica*	Motha Karmal	10	5
30.	*Dolichandrone falcata*	Medhshingi	10	0
31.	*Erythrina stricta*	Raan Pangara	35	12
32.	*Erythrina variegata*	Pangara	0	13
33.	*Ficus benghalensis*	Badh	35	30
34.	*Ficus hispida*	Hairy Fig	0	5
35.	*Ficus racemosa*	Goolar	35	17
36.	*Ficus religiosa*	Peepal	35	15
37.	*Ficus virens*	Pilkhan	35	11
38.	*Gmelina arborea*	Shivan	50	33
39.	*Heterophragma quadriloculare*	Waras	25	10
40.	*Holarrhena pubescens*	Panthara Kuda	15	8
41.	*Holoptelea integrifolia*	Kanju	55	35
42.	*Lagerstroemia speciosa*	Jarul	45	29
43.	*Lawsonia inermis*	Henna	0	6
44.	*Limonia acidissima*	Kavath	30	11
45.	*Macaranga peltata*	Chandada	25	17
46.	*Madhuca longifolia var. latifolia*	Mahua	45	21
47.	*Magnolia champaca*	Sonchafa	30	2
48.	*Melia azedarach*	Bakain	50	19
49.	*Mimusops elengi*	Bakul	45	34
50.	*Moringa oleifera*	Drumstick	0	1
51.	*Neolamarckia cadamba*	Kadamb	35	28

52.	*Nyctanthes arbor-tristis*	Parijaat	55	37
53.	*Oroxylum indicum*	Tetu	45	33
54.	*Phyllanthus emblica*	Awla	45	26
55.	*Polyalthia longifolia*	False Ashok	25	25
56.	*Pongamia pinnata*	Karanj	45	31
57.	*Premna serratifolia*	Agnimanth	45	0
58.	*Putranjiva roxburghii*	Putranjiva	20	20
59.	*Sapindus mukorossi*	Reetha	40	7
60.	*Saraca asoca*	Sita Ashok	25	23
61.	*Schleichera oleosa*	Kusum	10	7
62.	*Senna surattensis*	Motha Tarvad	35	9
63.	*Sterculia foetida*	Jungli Badam	40	24
64.	*Syzygium cumini*	Jambhul	40	19
65.	*Syzygium salicifolium*	Pan Jambhul	30	17
66.	*Terminalia arjuna*	Arjun	40	16
67.	*Terminalia bellirica*	Baheda	35	21
68.	*Terminalia catappa*	Badam	35	17
69.	*Vitex negundo*	Nirgudi	30	20
70.	*Wrightia arborea*	Tambda Kuda	30	13
71.	*Wrightia tinctoria*	Kala Kuda	30	19
72.	*Ziziphus rugosa*	Toran	35	16
Total			**2,100**	**1,197**

Table 8. Species list and count of the plantation at Byculla site

A total of 62 out of 66 species of trees mentioned in the species list provided by the plantation partner, were found on the site. The four species that were missing are Babool, Dandus, Medhshingi, and Agnimanth. A total of 6 new species were also observed at this site were, the species were, Neem, Samudraphal, Pangara (E. variegata), Hairy Fig, Henna, and Drumstick.

Recommendations:

- It is recommended to keep a track of site conditions and periodic updates about existing trees count before the audit.
- To provide reliable SPOC (who is technically sound & best known to the plantation partner, trusted by the internal team of NFS) so that not much time is wasted in re-visiting.
- Pest Infections were observed in *Pongamia pinnata, Bauhinia variegata, Cassia fistula, Alstonia scholaris, Ziziphus rugosa* plants.
- Fungal infections were observed in *Erythrina variegata* and some plants with corky bark. Carbendazim fungicide and Borax are recommended to be used both as curative and preventive for the control of diseases in plant species.

Fig. 39. Scatter Map image of the geotagged coordinates of Byculla plantation site

4.1.7. Sanjay Gandhi National Park

Another plantation site of CRISIL is located at the Sanjay Gandhi National Park, in Mumbai. The site is managed and maintained by the plantation partner Nature Forever Society. A total of 2,880 saplings were planted at the site by the plantation partner through the Miyawaki technique.

The physical tagging activity was carried out at the site on 29th October 2021 by the NFS team. Since there is no network connectivity inside the national park, the geotagging activity could not be carried out by the CERE team. However, an inventory of all the trees species found on site was manually created by the team. The same inventory of the species list is used for the calculation of the carbon sequestration potential of the site. CERE has found 1,761 trees surviving at this site out of 2,880 trees plantation.

S. No.	Location	No. of Trees Planted	No. of Trees to be Geotagged	No. of Trees found at the site	No. of Trees Geotagged	No. of Physically Observed Trees (besides geotagging)	Survival Rate (%)
1.	Byculla Zoo	2,880	920	1,761	-	1,761	61.15%

Observations:

- The site is located behind the Tiger Safari Office, adjacent to the natural vegetation. The plantation is done on a single plot, covering an area of 418 sq. m. according to the information provided by the plantation partner.

Fig. 40. Image of the plantation plot protected with fencing

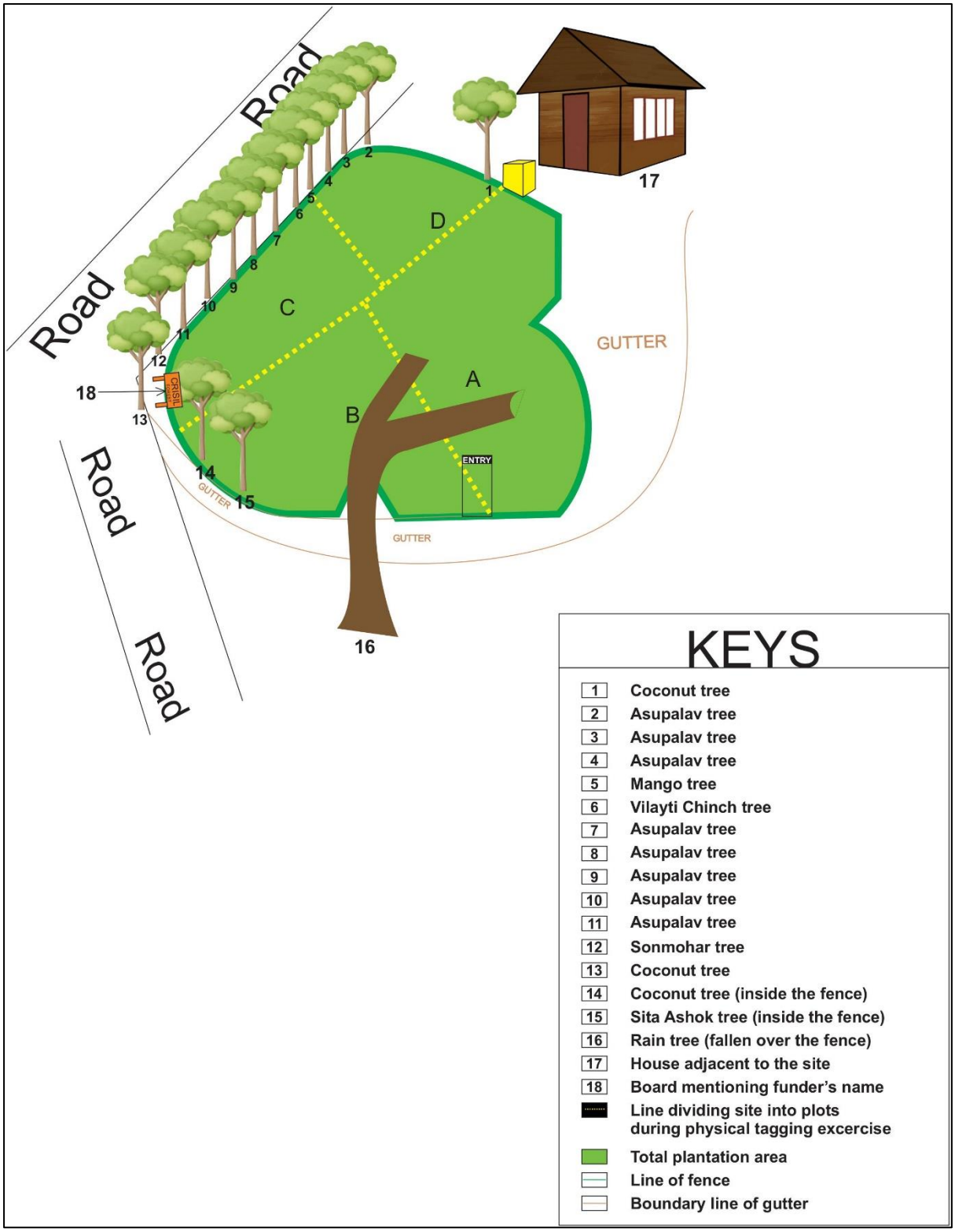
- The site has an even land surface. A board mentioning the funder's name was present at the site.
- The soil type at the site was clay, silty, fertile garden soil. The height of the trees was observed to be in between the range of 1ft – 15ft. The approximate distance of 1ft – 1.5ft was maintained between the saplings. Plantation pits were deep enough.
- The irrigation at the site is done using hosepipes. No water clogging was observed at the site. The site was fenced completely and no trespassing or signs of cattle grazing were observed at the site.
- The support sticks were not found to be present with the plants, due to which many plants had fallen over each other and suffered damage due to lack of support.
- A total of 54 species of trees were found on the site. 3 plant species out of 55 mentioned in the species list provided by the plantation partner were not found surviving on site: Bitter Albizia, Mock Bodh tree and Elephant Apple.
- There were 2 new plant species found on site but were not present in the partner's list: Karanj and Indian Charcoal Tree.
- Infestations were observed in *Syzygium cumini, Terminalia bellirica, Terminalia arjuna, Ficus arnottiana* and *Holoptelea integrifolia.* Some plants were damaged while de-weeding which was done before the site visit.

Fig. 41. Crisil's representative supervising the work

Fig. 42. CERE's geotaggers creating species wise tree inventory

Fig. 43. Damaged Mahua plant due to lack of support

Fig. 44. Bifurcation done at the plantation site to carry out the physical tagging accurately



Diagrammatic representation of Crisil's SGNP plantation plot

The site was divided into 4 different sections as Section A, Section B, Section C & Section D for ease of carrying out the physical tagging of the trees and preparing species wise list of all the surviving trees at the site.

Species List:

S. No.	Scientific Name	Common Name	No. of Trees Planted	No. of Trees found on site
1.	*Acacia catechu*	Khair	70	42
2.	*Acacia ferruginea*	Safed Khair	70	18
3.	*Acrocarpus fraxinifolius*	Pink Cedar	5	5
4.	*Adenanthera pavonina*	Thorla Gunj	35	30
5.	*Aegle marmelos*	Bel	70	47
6.	*Albizia amara*	Bitter Albizia	5	0
7.	*Albizia lebbeck*	Siris	70	16
8.	*Albizia odoratissima*	Kala Siris	25	22
9.	*Albizia procera*	Safed Siris	60	16
10.	*Artocarpus heterophyllus*	Phanas	75	61
11.	*Bauhinia malabarica*	Amli	5	5
12.	*Bauhinia purpurea*	Kanchan	95	75
13.	*Bauhinia racemosa*	Apta	95	26
14.	*Bombax ceiba*	Semal	70	32
15.	*Butea monosperma*	Palash	75	19
16.	*Careya arborea*	Kumbhi	5	8
17.	*Chukrasia tabularis*	Chukrasia	75	71
18.	*Cochlospermum religiosum*	Yellow Slik Cotton	5	1
19.	*Cordia dichotoma*	Bhokar	5	4
20.	*Dalbergia latifolia*	Kala shisham	40	25
21.	*Dillenia indica*	Motha Karmal	5	0
22.	*Dolichandrone falcata*	Medhshingi	5	4
23.	*Erythrina stricta*	Ranpangara	25	14
24.	*Erythrina variegata*	Pangara	25	18

25.	*Ficus amplissima*	Pimpri	5	3
26.	*Ficus arnottiana*	Pipali	5	2
27.	*Ficus benghalensis*	Badh	95	90
28.	*Ficus racemosa*	Goolar	95	59
29.	*Ficus religiosa*	Peepal	5	5
30.	*Ficus rumphii*	Kabaipipal	5	0
31.	*Gmelina arborea*	Shivan	95	75
32.	*Holoptelea integrifolia*	Kanju	95	80
33.	*Lagerstroemia speciosa*	Jarul	95	65
34.	*Limonia acidissima*	Kavath	95	73
35.	*Madhuca longifolia var. latifolia*	Mahua	95	45
36.	*Magnolia champaca*	Sonchafa	5	3
37.	*Mallotus philippensis*	Kaamala	5	4
38.	*Millingtonia hortensis*	Indian Cork Tree	5	3
39.	*Mimusops elengi*	Bakul	90	80
40.	*Morus alba*	Shahtoot	5	5
41.	*Nyctanthes arbor-tristis*	Parijaat	95	81
42.	*Oroxylum indicum*	Tetu	75	37
43.	*Phyllanthus emblica*	Awla	75	35
44.	*Pongamia pinnata*	Karanj	0	1
45.	*Prosopis cineraria*	Khejri	5	2
46.	*Putranjiva roxburghii*	Putranjiva	5	4
47.	*Sapindus mukorossi*	Reetha	95	62
48.	*Saraca asoca*	Sita Ashok	45	40
49.	*Syzygium cumini*	Jambhul	95	57
50.	*Terminalia arjuna*	Arjun	95	57
51.	*Terminalia bellirica*	Baheda	75	21

52.	*Terminalia chebula*	Hirda	75	27
53.	*Trema orientale*	Indian Charcoal Tree	0	4
54.	*Vitex negundo*	Chaste Tree	95	75
55.	*Vitex negundo (Black)*	Chaste Tree - Black	95	72
56.	*Wrightia arborea*	Tambda Kuda	50	21
57.	*Wrightia tinctoria*	Kala Kuda	95	14
Total			**2,880**	**1,761**

Table 9. Species list and count of the plantation at Byculla site

Site-wise Recommendations:

- It is recommended to ensure the safety of the plants during de-weeding.
- Fungal Infections were observed in *Syzygium cumini, Terminalia bellirica, Terminalia arjuna, Ficus arnottiana* and *Holoptelea integrifolia* plants.
- Carbendazim fungicide and Borax is recommended to be used both as curative and preventive for the control of diseases in plant species.
- Foliar spray of Bavistin fungicidal solution (0.1%) is recommended to treat the fungal leaf spot disease on *Ficus arnottiana* species.
- It is recommended to make sure the plants have support sticks to avoid any damage to the plants.

4.1.8. Rayta village, Titwala

The plantation at Rayta village is located in Titwala. The site is an open plot that belongs to the villagers and was previously used for cattle grazing. The plantation at the site is managed by the partner Grow Trees. They have planted 25,000* trees at the site, out of which 8,000 were to be geotagged by CERE. The geotagging activity at Titwala was carried out from 11th – 16th of August 2021. (The plantation partner had shared a species list with the total count of 25,600 trees with CERE, so the analysis was done accordingly)

CERE's geotagging team has geotagged a total of 8,392 trees on the site. However, the area covered by the sample size of 8,392 trees had a mortality of 4.16%. Since some part of the plantation site was inaccessible to carry out geotagging, the survival rate of the sample size, which is 95.84%, is then extrapolated for the total plantation. So accordingly, Carbon Sequestration is calculated for 23,958 trees present at this site (according to the survival rate).

S. No.	Location	No. of Trees Planted	No. of Trees to be Geotagged	No. of Trees found at the site	No. of Trees Geotagged	No. of Physically Observed Trees (besides geotagging)	Survival Rate (%)
1.	Rayta Village, Titwala	25,000	8,000	23,958	8,392	-	95.83%

Fig. 45. Image of the plantation plot

Observations:

- It is a mass plantation site divided into six sections, i.e. A, B, C, D, E and F. Sections E and F are further divided into E1, E2, E3, E4 and F1, F2, F3 respectively. The total area under the plantation is around 15 – 20 acres (60,000 – 80,000 sq. m). The site is flat land, surrounded by a road on one side and the Ulhas River on the other.
- The site has fertile, clayey-type soil. Support sticks were present mostly for the plants in sections A to D. The irrigation at the site is done through the drenching method using the pipes. Waterlogging was seen at a spot in section A.
- According to the list provided by the partner, 25,600 saplings of 12 species were planted at the site. However, 17 species were observed at the site. The five more species found are Amaltas, Kassod, Hairy Fig, Chinch and Saag. Since all these newly found species were not in the species list shared by the partner, they are not accounted for the carbon sequestration. 419 Sag trees were geotagged and they are also included in the total no. of trees geotagged at this site.
- Fencing was done previously on the site, but it was observed to be broken due to the flood. Now, natural fencing has been done. Trespassing was observed at the site, however, there was no sign of cattle grazing.
- De-weeding was not done at the site due to the monsoon. Some damage to the saplings due to risen water level of the adjacent river was evident. However, many saplings managed to recover. The saplings of Karanj were seen to be infested by caterpillars.
- Some saplings were recovering from the shock and some were replanted. These saplings were around 1ft – 2ft in height. The other trees that sustained well were 5ft – 6ft in height. Out of the total geo-tagged trees, 127 were found to be alive but without any leaves. These are plants that are reviving from the shock. A total of 347 species were observed to be dead and dried at the site.

Fig. 46. Sapling with the support stick

Fig. 47. Distance between two saplings

Fig. 48. Ullas River adjacent to the plantation plot

Fig. 49. Image showing rise in water level (flood)

Fig. 50. Caterpillar infestation on leaves of Pongamia pinnata (Karanj)

Species List:

S. No.	Scientific Name	Common Name	No. of Trees Planted	No. of Trees found at the site
1.	*Acacia auriculiformis*	Earleaf Acacia	6,700	6421
2.	*Anacardium occidentale*	Cashew	1,050	1006
3.	*Annona squamosa*	Custard Apple	1,750	1677
4.	*Artocarpus heterophyllus*	Jackfruit	850	815
5.	*Bambusa vulgaris*	Bamboo	190	182
6.	*Citrus limon*	Lemon	350	335
7.	*Dalbergia sissoo*	Sheesham	3,650	3498
8.	*Mangifera indica*	Mango	550	527
9.	*Phyllanthus emblica*	Amla	350	335
10.	*Pongamia pinnata*	Karanj	6,150	5894
11.	*Psidium guajava*	Guava	1,460	1399
12.	*Syzygium cumini*	Java Plum (Jamun)	1,950	1869
Total			**25,000**	**23,958**

Table 10. Species list and count of the plantation at Titwala site

Recommendations:

- Numbering of the saplings while plantation is recommended as it will help ground staff to keep a track of the saplings' species in case of replantation.
- De-weeding should be done at regular intervals to maintain the accessibility to the plantation. Proper fencing should be done to avoid trespassing by people.
- Controlling caterpillar infestation on leaves using microbial insecticides such as BTK (*Bacillus thuringiensis*) would be beneficial. Some fungal infestations were also observed due to water clogging. Thus, the use of fungicides or prevention of water clogging is recommended.
- It is recommended to put support sticks while the plantation to avoid plant damage.

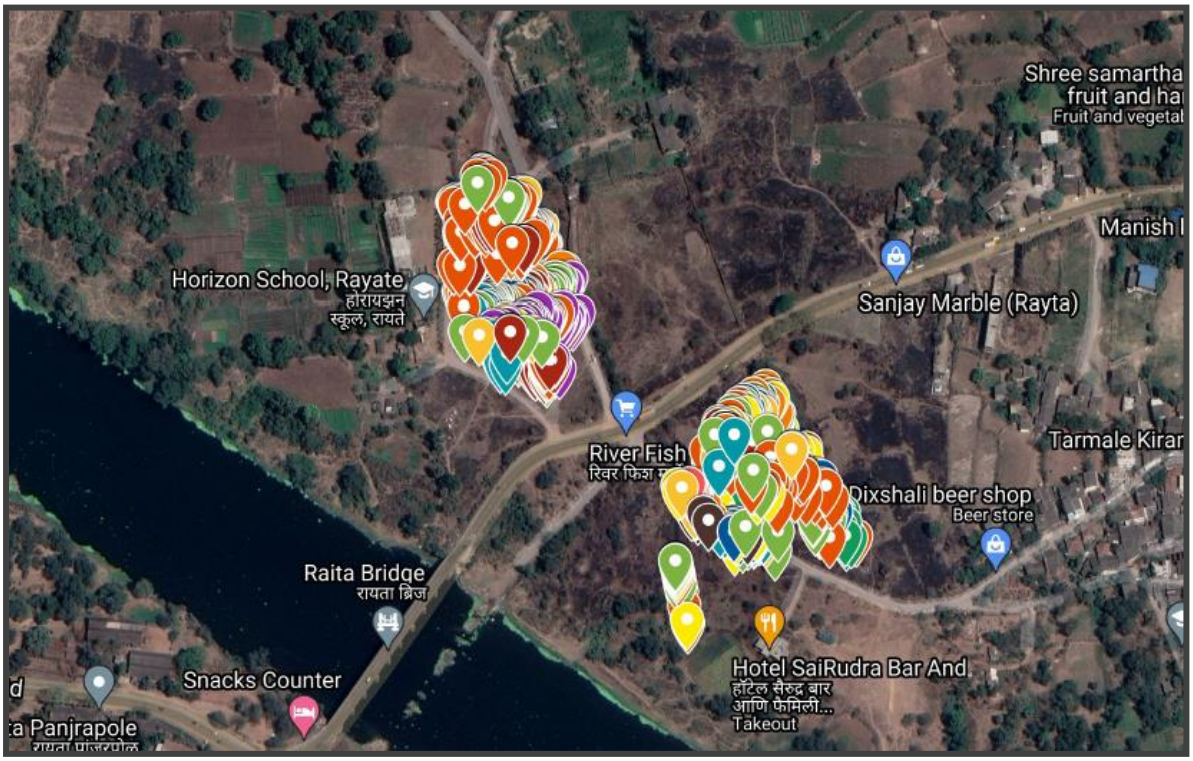


Fig. 51. Scatter map image of the geotagged coordinates at Titwala site

4.2. PUNE PLANTATION SITES

Pune has two plantation sites of CRISIL Foundation: Chaturshrungi and Linear Garden. The site at Chaturshrungi is maintained by the plantation partner Green Hills Group (in collaboration with United Ways of Mumbai. It is a mass plantation site over a hill slope. The other site is at Linear Garden, which is a Miyawaki plantation and is maintained by the plantation partner Nature Forever Society.

1. Chaturshrungi Hills

2. Linear Garden

4.2.1. Chaturshrungi, Pune

The plantation site is on a hill slope adjacent to the Chaturshrungi temple in Pune. The area is owned by the Municipal corporation of Pune. Greens Hills Group (in collaboration with United Way of Mumbai) is the plantation partner and maintains the site. The plantation partner had planted a total of 500 trees at this hill site in 2019 and more than 1000 trees in 2018. A total of 300 trees were to be geotagged at the site from 2019's plantation, while 200 trees were to be retagged from 2018's plantation. CERE carried out the geotagging at the site in two parts. The team made the first visit to the site on 14th August 2021 and geotagged 203 trees from 2019's plantation. Another 125 trees were geotagged during the second visit on the 18th of October 2021. Also, another 216 trees from 2018's plantation were retagged during the second visit. Therefore, the overall trees tagged during the overall geotagging exercise at the Chaturshrungi site are 544*.

S. No.	Location	No. of Trees Planted	No. of Trees to be Geotagged	No. of Trees found at the site	No. of Trees Geotagged	No. of Physically Observed Trees (besides geotagging)	Survival Rate (%)
1.	Chaturshrungi, Pune	500	500	500	544*	-	100%

Observations:

- The plantation area is approximately 4 acres (16,187 sq. m) according to the plantation partner. The site is a hill slope surrounded by open hills and multiple plantation projects. The plantation is done along the slope in trenches to prevent soil erosion and harvest rainwater for trees.

- The soil type is loamy soil below and sandy soil at the surface with enough humus. It is very fertile and the site is rich in biodiversity. The land has a slope with deep trenches. Trees guards as well as support sticks were not present and not needed for the plants. Plantation pits are deep enough.
- Irrigation at the sites is done by drip irrigation technique. The saplings are also irrigated by drenching the rainwater into trenches and through a well. Water clogging was not observed, except in some low-lying areas where water got temporarily collected which led to damage and fungal infections in some plants which were affected.
- It is a mass plantation and the average height of saplings was observed to be between 3ft – 7ft. The distance maintained between individual saplings was 12ft – 15ft. De-weeding was not done at the site due to the monsoon, shall be done in October to avoid fires since grasses have grown too tall.
- A total of 39 different species were observed at 2019's plantation at Chaturshrungi. The list of 34 species was provided by the partner, while 5 new species were found on the site. The species were: Bor, Indian Cork Tree, Subabul, Red Sandlewood, and Bel.
- Plants of 36 different species from 2018's plantation were observed and geotagged at the site.
- Leaves of *Pongamia pinatta* were seen to be infected by Gall disease. Invasive plant species like *Lantana camara*, *Leucaena leucocephala, Trema orentalis* were observed on the site, which may damage or invade the plantation area in future. Some dried trees and trees without leaves were observed at the site.
- Continuous fencing is created across the borders of the sites. No signs of cattle grazing or trespassing were observed.

Fig. 52. Image of the plantation site

Fig. 53. Continuous fencing done at the site

Fig. 54. The team accessing the trees planted in different trenches

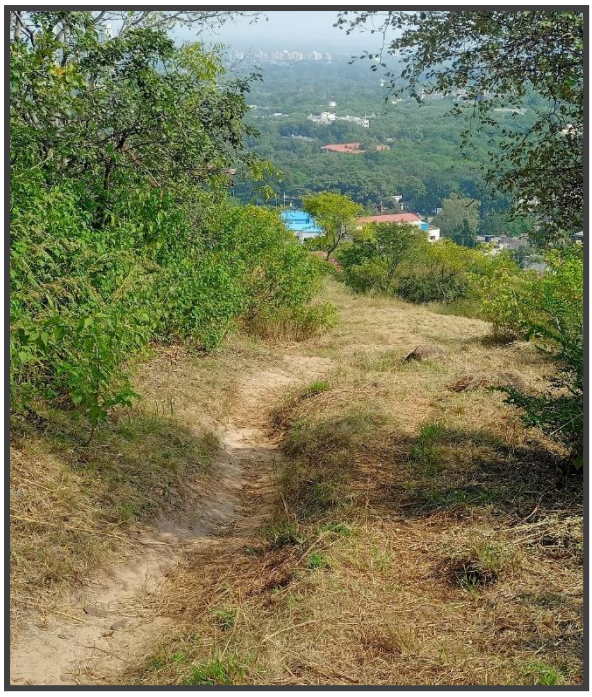


Fig. 55. Plantation done in trenches along the slope of hill

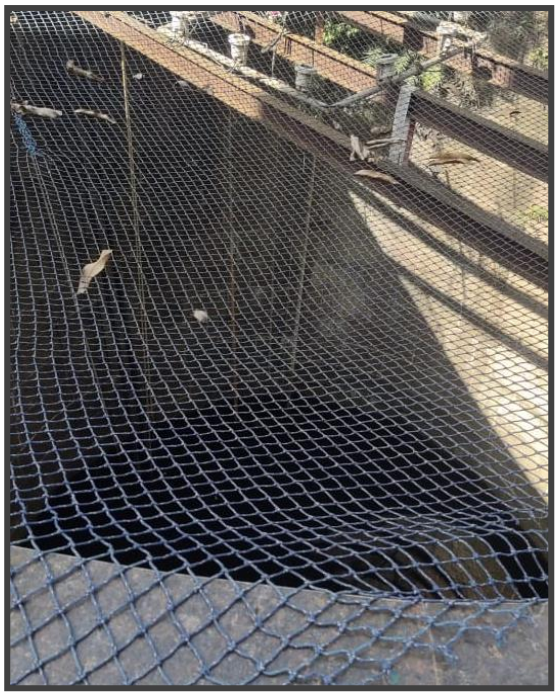


Fig. 56. The well as a water-source for the plantation

Fig. 57. Pest infestation seen on Syzygium cumini leaves

Fig. 58. Fungal Infection observed on a plant

Species List of 2019's plantation:

S. No.	Scientific Name	Common Name	No. of Trees Planted	No. of Trees Found on-site
1.	*Albizia lebbeck*	Shirish	9	9
2.	*Alstonia scholaris*	Saptaparni	2	2
3.	*Annona squamosa*	Sitafal	1	1
4.	*Azadirachta indica*	Neem	57	57
5.	*Bauhinia racemosa*	Apta	10	10
6.	*Bauhinia variegata*	Kanchan	27	27
7.	*Bombax ceiba*	Katesavar	53	53
8.	*Bombax insigne*	Sawar	6	6
9.	*Butea monosperma*	Palash	9	9
10.	*Carissa carandas*	Karvand	1	1
11.	*Cassia fistula*	Bahava	9	9
12.	*Cochlospermum religiosum*	Yellow Cotton Silk	2	2
13.	*Cordia dichotoma*	Bhokar	5	5
14.	*Dalbergia lanceolaria*	Dandus	3	3
15.	*Dalbergia latifolia*	Shisav	22	22
16.	*Dalbergia sissoo*	Sheesham	7	7
17.	*Erythrina variegata*	Pangara	3	3
18.	*Ficus racemosa*	Umber	3	3
19.	*Ficus religiosa*	Peepal	2	2
20.	*Holoptelea integrifolia*	Vavla	5	5
21.	*Lagerstroemia speciosa*	Taman	22	22
22.	*Madhuca longifolia*	Moh	5	5
23.	*Mimusops elengi*	Bakul	4	4
24.	*Moringa oleifera*	Shevga	4	4

25.	*Phyllanthus emblica*	Awla	16	16
26.	*Plumeria alba*	Plumeria	1	1
27.	Pongamia pinnata	Karanj	83	83
28.	Pterospermum acerifolium	Kanakchampa	5	5
29.	Putranjiva roxburghii	Putranjiva	3	3
30.	Santalum album	Chandan	2	2
31.	Tamarindus indica	Chinch	63	63
32.	Terminalia arjuna	Arjun	33	33
33.	Terminalia bellirica	Baheda	13	13
34.	Trema orientale	Ghol	1	1
35.	Other	Unknown	19	9
Total			**510**	**500**

Table 11. Species List and count of the 2019's plantation at Chaturshrungi site

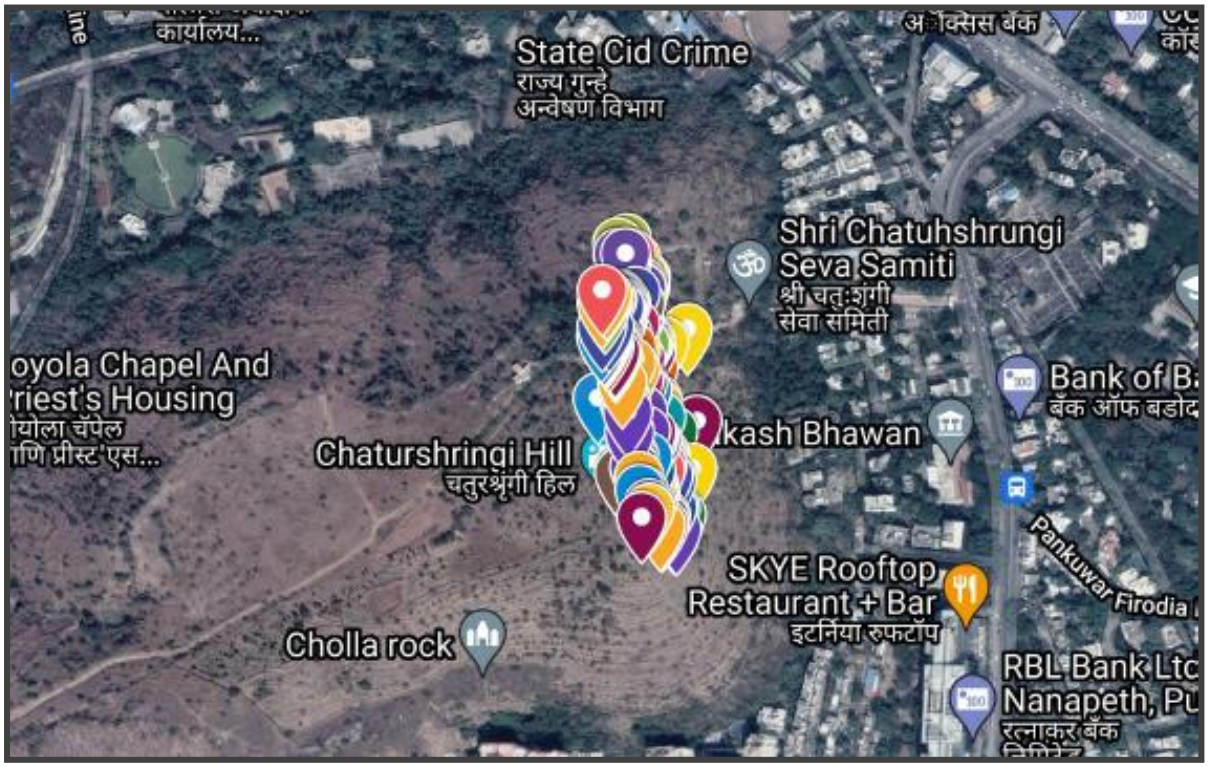


Fig. 59. Scatter Map image of the geotagged coordinates for 2019's plantation at Chaturshrungi site

Species List of the trees re-tagged from 2018's plantation at Chaturshrungi site:

S. No.	Scientific Name	Common Name	No of Trees Geotagged
1.	*Acacia catechu*	Khair	2
2.	*Aegle marmelos*	Bel	4
3.	*Albizia lebbeck*	Shirish	4
4.	*Alstonia scholaris*	Saptaparni	3
5.	*Annona sqaumosa*	Sitaphal	1
6.	*Areca catechu*	Areca palm	2
7.	*Azadirachta indica*	Neem	28
8.	*Bauhinia racemosa*	Apta	8
9.	*Bauhinia variegata*	Kanchan	27
10.	*Bombax ceiba*	Katesawar	6
11.	*Butea monosperma*	Palas	8
12.	*Carissa carandas*	Karvand	3
13.	*Cordia dichotoma*	Bhokar	3
14.	*Dalbergia lancelaria*	Dandus	2
15.	*Dalbergia sissoo*	Shisam	21
16.	*Erythrina variegata*	Pangara	1
17.	*Ficus racemosa*	Umbar	10
18.	*Ficus religiosa*	Peepal	4
19.	*Lagerstroemia speciosa*	Jarul	4

20.	*Mangifera indica*	Mango	1
21.	*Millingtonia hortensis*	Indian cork tree	2
22.	*Mimusops elengi*	Bakul	2
23.	*Morinda citrifolia*	Bartondi (Noni)	2
24.	*Moringa oleifera*	Drumstick	4
25.	*Nyctanthes arbor-tristis*	Parijatak	1
26.	*Oroxylum indicum*	Tetu	1
27.	*Phyllanthus emblica*	Awla	23
28.	*Pongamia pinnata*	Karanj	6
29.	*Putranjiva roxburghii*	Putranjiva	3
30.	*Santalum album*	Chandan	1
31.	*Syzygium cumini*	Jamun	1
32.	*Tamarindus indica*	Chinch	8
33.	*Tecoma stans*	Tecoma	3
34.	*Terminalia arjuna*	Arjun	9
35.	*Terminalia bellirica*	Beheda	6
36.	*Ziziphus jujuba*	Bor	2
Total			**216**

Table 12. Species List and count of the trees geotagged from 2018's plantation at Chatursrungi site.

The trees from Crisil's 2018's plantation are growing well and have attained heights of 8 feet to 12 feet. The plantations are growing well.

Fig. 60. Scatter Map image of the geotagged coordinates for 2019's plantation at Chaturshrungi site

Site-wise Recommendations:

- Periodic cleaning of the site may help avoid forest fires.
- The site must be kept safe from invasive plant species by periodic cutting and proper disposal of the remains.
- Fungal Infections were seen in many plant species. Carbendazim fungicide and Borax are recommended to be used both as curative and preventive for control of diseases in plant species.
- Gall disease was seen on *Pongamia pinnata* species. Galls can be controlled by manually removing the foliage and destruction by burning. It is recommended to control the spreading of disease by spraying 1% monocrotophos and dimethoate insecticides on a healthy plant.

4.2.2. Linear Garden

The plantation site at Linear Garden is located in Pimpri, Pune. The site is owned by Pune Municipal Corporation. The site was afforested by planting 1,800 trees through the Miyawaki technique by the plantation partner Nature Forever Society. The sample size of the plantation to be geotagged for the site was 730. On 18th October 2021, the NFS team carried out physical tagging of the trees at the site, post which the geotagging exercise was conducted by the CERE team. The total number of trees found surviving on the ground is 970 and the number of trees geotagged is 756.

S. No.	Location	No. of Trees Planted	No. of Trees to be Geotagged	No. of Trees found at the site	No. of Trees Geotagged	**No. of Physically Observed Trees (besides geotagging)**	Survival Rate (%)
1.	Linear Garden, Pune	1,800	730	970	756	214	53.89%

Observations:

- The plantation is done in a single plot, covering a total area of approx. 186 sq. m. The site is adjacent to the 'Seven Star Lane' road. The board mentioning the funder's name was present at the entrance of the site.
- The surface was even and flat land. Fertile, garden soil was observed at the plantation site. Support sticks were not found with the plants. Plantation pits were found to be deep enough.

Fig. 61. Front view of the plantation

- The average height of the saplings was observed to be in the range of 6 inches to 20 ft (herbs and shrubs included). Approximately 1 ft to 1.5 ft distance was maintained between individual saplings.
- Watering of the trees is done through drench irrigation using a hose pipe. No water clogging was observed at the site. The site was protected with a continuous fence. No trespassing or cattle grazing was observed at the site.
- Out of 50 plant species mentioned in the species list provided by the plantation partner, 5 species were not found on the site. These include White Siris, Jackfruit, Indian Thorny Bamboo, White Fig, Pride of India.
- Four extra species were found and geotagged on the site, namely: Apta, Sagargota, Yellow Silk Cotton, and Kaner. A total of 49 plant species were geotagged on the site.
- Pest infestations were observed on *Millettia pinnata*, *Terminalia catappa* and *Syzygium cumini***.** Plant damage was observed due to a lack of support sticks.

Fig. 62. Team members geotagging the plantation

Fig. 63. Back view of the plantation

Species List:

S. No.	Scientific Name	Common Name	No. of Trees Planted	No. of Trees found on site
1.	*Acacia chundra*	Lal Khair	30	10
2.	*Acacia ferruginea*	Safed Khair	30	19
3.	*Acacia pennata*	Climbing Acacia	35	11
4.	*Adenanthera pavonina*	Thorla Gunj	35	35
5.	*Aegle marmelos*	Bel	40	26
6.	*Albizia lebbeck*	Siris	45	7
7.	*Albizia odoratissima*	Kala Siris	35	9
8.	*Albizia procera*	Safed Siris	35	0
9.	*Alstonia scholaris*	Saptaparni	50	26
10.	*Artocarpus heterophyllus*	Jackfruit	40	0
11.	*Azadirachta indica*	Neem	25	11
12.	*Bambusa bambos*	Baans	30	0
13.	*Bauhinia acuminata*	Safed Kachnar	30	5
14.	*Bauhinia purpurea*	Purple Kachnar	35	10
15.	*Bauhinia racemosa*	Apta	0	3
16.	*Bauhinia variegata*	Kachnar	35	15
17.	*Bombax ceiba*	Sawar	50	13
18.	*Bombax insigne*	Dev Sawar	55	17
19.	*Butea monosperma*	Palash	35	5
20.	*Caesalpinia bonduc*	Sagargota	0	90
21.	*Careya arborea*	Kumbhi	15	9
22.	*Carissa spinarum*	Karvand	45	42
23.	*Cassia fistula*	Amaltas	35	23
24.	*Cochlospermum religiosum*	Yellow Silk Cotton	0	3

25.	*Cordia dichotoma*	Bhokar	25	10
26.	*Dendrocalamus strictus*	Hard Bamboo/Bans	40	48
27.	*Erythrina stricta*	Raan Pangara	35	5
28.	*Ficus benghalensis*	Wad	45	36
29.	*Ficus racemosa*	Umbar	35	18
30.	*Ficus religiosa*	Peepal	45	15
31.	*Ficus virens*	White Fig	10	0
32.	*Gmelina arborea*	Shivan	55	34
33.	*Lagerstroemia speciosa*	Pride of india	45	0
34.	*Limonia acidissima*	Kavath	25	20
35.	*Macaranga peltata*	Chandada	25	16
36.	*Magnolia champaca*	Champa	35	2
37.	*Melia azedarach*	Bakan Neem	45	37
38.	*Mimusops elengi*	Bakul	40	20
39.	*Nerium oleander*	Kaner	0	1
40.	*Nyctanthes arbor-tristis*	Parijatak	50	10
41.	*Oroxylum indicum*	Tetu	30	16
42.	*Polyalthia longifolia*	False Ashok	45	27
43.	*Pongamia pinnata*	Karanj	50	45
44.	*Pterygota alata*	Buddha Coconut	20	7
45.	*Putranjiva roxburghii*	Putranjiva	20	5
46.	*Sapindus mukorossi*	Reetha	30	3
47.	*Saraca asoca*	Sita Ashok	15	2
48.	*Senna siamea*	Kassod	45	50
49.	*Senna surattensis*	Glaucus Cassia	45	28
50.	*Syzygium cumini*	Jambhul	55	44
51.	*Syzygium salicifolium*	Pan Jambhul	40	23

52.	*Terminalia catappa*	Badam	50	37
53.	*Wrightia arborea*	Tambda Kuda	25	4
54.	*Wrightia tinctoria*	Kala Kuda	20	18
Total			**1,810***	**970**

Table 13. Species list and count of the plantation at Linear Garden site

*The plantation partner had shared a species list consisting of 1810 trees in total instead of 1800 trees.

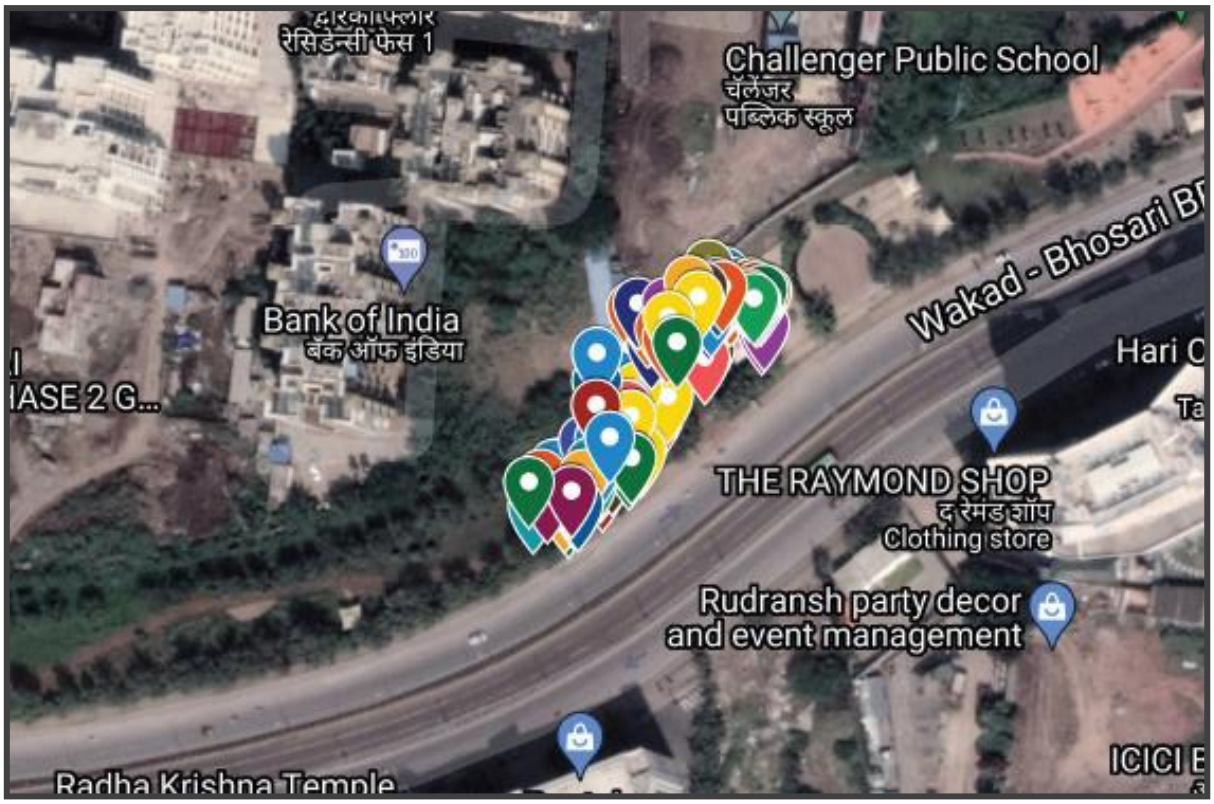


Fig. 64. Scatter map image of the geotagged coordinates at Linear Garden site

Site-wise Recommendations:

- It is recommended to ensure the safety of the plants by providing support sticks.
- Fungal Infections were observed in *Pongamia pinnata*, *Terminalia catappa* and *Syzygium cumini* plants. Carbendazim fungicide and Borax is recommended to be used both as curative and preventive for control of diseases in plant species.
- To decrease the mortality rate on the site, regular surveys for survival checks and plantation health checks must be done.

5. DATA ANALYSIS AND CARBON SEQUESTRATION

5.1. Highlights of CRISIL Plantation

The project aimed at conducting the carbon sequestration study of different plantations of CRISIL Foundation in the cities of Mumbai and Pune. The study also included the assessment of the overall health and growth of the plantations. The plantation was carried out for 39,680 plants at 10 locations. The type of plantation was conventional at four sites, while Miyawaki plantation was done at six of the ten sites.
A total of **33,368** trees were collectively found at the plantation sites, out of which **13,574** trees were geotagged by CERE.

The site with the largest plantation was Titwala, where a total of 23,598 trees were found at the site. It was followed by the plantation at the Sanjay Gandhi National Park with 1,761 trees and the Byculla plantation with 1,197 trees. However, the highest species diversity was found at the Ambrosia Garden site in Powai, with 59 species present at the site.

The site with the highest survival rate was at the Water Filtration Plant - Bhandup site, and the Tetavalli village, Rabale plantation site with a 100% survival rate. While the lowest survival rate recorded was at Mahul with 18%. Only 180 trees were found alive at the site and the mortality rate was 82%.

The soil quality was better at the sites like Bhandup, Rabale, and Chaturshrungi. Soil and water-conserving structures like contour bunding and trenches were built at the Chaturshrungi site. The bunds help in soil erosion on the slopes, while the rainwater gets conserved into the trenches and a well nearby. The site was also rich in biodiversity.

5.2. Species Distribution:

The overall plantation of 39,680 trees at ten different sites of the CRISIL Foundation is comprised of collectively 135 different species of plants.

The species with the highest number of the count was Ear Leaf Acacia *(Acacia auriculiformis)*, with 6,421 trees planted. Followed by Karanj *(Pongamia pinnata)* with 6,332 trees and Shisham (*Dalbergia sissoo*) with 3,581 trees planted. Some of the other trees planted in abundance were Jamun (*Syzygium cumini)* with 2,269 trees, Sitaphal (*Annona squamosa*) with 1,688 trees, Amrud (*Psidium guajava*) with 1,440 trees, Cashew (*Anacardium occidentale*) with 1,009 trees, Jackfruit (*Artocarpus heterophyllus*) with 936 trees, Mango (Mangifera indica) with 666 trees and Awla (*Phyllanthus emblica*) with 521 trees planted.

Many other species were planted in lesser quantities, which includes Sandalwood tree, Canon ball tree, Henna, Castor Oil plant, and Kokum.

The following species list displays the 135 different species and their count in the overall plantation of CRISIL Foundation:

S. No.	Scientific Name	Common Name	No. of Trees Found	Native/ Non-native
1.	*Acacia auriculiformis*	Ear Leaf Acacia	6421	Native
2.	*Acacia ferruginea*	Safed Khair	69	Native
3.	*Acacia nilotica*	Babool	3	Native
4.	*Acacia catechu*	Khair	62	Native
5.	*Acacia chundra*	Laal Khair	10	Native
6.	*Acacia pennata*	Climbing Wattle	11	Native
7.	*Acrocarpus fraxinifolius*	Pink Cedar	5	Native
8.	*Adenanthera pavonina*	Thorla Gunj	87	Native
9.	*Aegle marmelos*	Bael	138	Native
10.	*Albizia lebbeck*	Black Shirish	77	Native
11.	*Albizia odoratissima*	Kala Shirish	44	Native
12.	*Albizia procera*	Safed Shirish	38	Native
13.	*Alstonia scholaris*	Saptaparni	278	Native
14.	*Anacardium occidentale*	Cashew	1009	Non-Native
15.	*Annona squamosa*	Sitaphal	1688	Native
16.	*Aphanamixis polystachya*	Pithraj	12	Native
17.	*Artocarpus heterophyllus*	Jackfruit	936	Native
18.	*Azadirachta indica*	Neem	240	Native

19.	*Bambusa bambos*	Bamboo	23	Native
20.	*Bambusa vulgaris*	Bamboo	194	Native
21.	*Barringtonia acutangula*	Samundarphal	8	Native
22.	*Bauhinia acuminata*	Safed Kachnar	36	Native
23.	*Bauhinia malabarica*	Malabar Bauhiinia	5	Native
24.	*Bauhinia purpurea*	Purple Kachnar	104	Native
25.	*Bauhinia racemosa*	Apta	78	Native
26.	*Bauhinia variegata*	Kachnar	317	Native
27.	*Bixa orellana*	Lipstick Tree	65	Non-Native
28.	*Bombax ceiba*	Silk Cotton Tree	119	Native
29.	*Bombax insigne*	Dev Sawar	39	Native
30.	*Butea monosperma*	Flame of the Forest	90	Native
31.	*Caesalpinia bonduc*	Sagargota	102	Non-Native
32.	*Caesalpinia decapetala*	Mysore Thorn	13	Native
33.	*Careya arborea*	Kumbhi	60	Native
34.	*Carissa carandas*	Karvanda	2	Native
35.	*Carissa spinarum*	Karonda	81	Native
36.	*Cascabela thevetia*	Bitti	61	Native
37.	*Cassia fistula*	Amaltas	185	Native
38.	*Ceiba pentandra*	Kapok	4	Native
39.	*Cestrum nocturnum*	Ratrani	1	Non-Native

40.	*Chukrasia tabularis*	Chukrasia	71	Native
41.	*Cinnamomum tamala*	Tamalpatra	18	Native
42.	*Citrus limon*	Lemon	379	Native
43.	*Cochlospermum religiosum*	Yellow Silk Cotton	9	Native
44.	*Cocos nucifera*	Coconut	110	Native
45.	*Cordia dichotoma*	Gundi	54	Native
46.	*Couroupita guianensis*	Canon Ball Tree	1	Non-Native
47.	*Dalbergia lanceolaria*	Pehi	3	Native
48.	*Dalbergia latifolia*	Black Rosewood	66	Native
49.	*Dalbergia sissoo*	Shisham	3581	Native
50.	*Delonix regia*	Gulmohor	27	Non-Native
51.	*Dendrocalamus strictus*	Male Bamboo	129	Native
52.	*Dillenia indica*	Elephant Apple	5	Native
53.	*Dolichandrone falcata*	Medhshingi	4	Native
54.	*Erythrina stricta*	Raan Pangara	49	Native
55.	*Erythrina variegata*	Pangara	63	Native
56.	*Ficus amplissima*	Pimpri	3	Native
57.	*Ficus arnottiana*	Indian Rock Fig	2	Native
58.	*Ficus benghalensis*	Banyan Tree	235	Native
59.	*Ficus hispida*	Hairy Fig	5	Native
60.	*Ficus racemosa*	Cluster Fig	223	Native

61.	*Ficus religiosa*	Peepal	91	Native
62.	*Ficus virens*	White Fig	16	Native
63.	*Garcinia indica*	Kokum	1	Native
64.	*Gardenia jasminoides*	Cape Jasmine	10	Native
65.	*Gmelina arborea*	Gamhar	165	Native
66.	*Grevillea robusta*	Silver Oak	156	Native
67.	*Heterophragma quadriloculare*	Waras	10	Native
68.	*Hibiscus rosa-sinensis*	Jaswandi	10	Native
69.	*Hibiscus syriacus*	Syrian Hibiscus	9	Non-Native
70.	*Holarrhena pubescens*	Pandhra Kuda	13	Native
71.	*Holoptelea integrifolia*	Papdi/Chilbil	133	Native
72.	*Justicia adathoda*	Adulsa	24	Native
73.	*Lagerstroemia indica*	Jarul	82	Native
74.	*Lagerstroemia speciosa*	Pride of India	151	Native
75.	*Lawsonia inermis*	Henna	12	Native
76.	*Limonia acidissima*	Wood Apple	117	Native
77.	*Macaranga peltata*	Chandada	43	Native
78.	*Madhuca longifolia*	Mahua	19	Native
79.	*Madhuca longifolia var. latifolia*	Mahua	66	Native
80.	*Magnolia champaca*	Son Champa	12	Native
81.	*Mallotus philippensis*	Kumkum	4	Native

82.	*Mangifera indica*	Mango	666	Native
83.	*Manilkara hexandra*	Khirni	19	Native
84.	*Manilkara zapota*	Chikoo	15	Native
85.	*Melia azedarach*	Bakanneem	66	Native
86.	*Millingtonia hortensis*	Indian Cork Tree	32	Native
87.	*Mimusops elengi*	Bakul	235	Native
88.	*Morinda citrifolia*	Noni	2	Native
89.	*Moringa oleifera*	Drumstick Tree	23	Native
90.	*Morus alba*	White Mulberry	5	Native
91.	*Murraya koenigii*	Curry Leaves Tree	7	Native
92.	*Murraya paniculata*	Kamini	2	Native
93.	*Neolamarckia cadamba*	Kadamb	57	Native
94.	*Nerium oleander*	Kaner	17	Native
95.	*Nyctanthes arbor-tristis*	Parijatak	134	Native
96.	*Oroxylum indicum*	Tetu	87	Native
97.	*Phyllanthus emblica*	Awla	521	Native
98.	*Pithecellobium dulce*	Vilayati Chinch	5	Native
99.	*Plumeria alba*	White Frangipani	1	Native
100.	*Polyalthia longifolia*	False Ashok	74	Native
101.	*Pongamia pinnata*	Karanj	6332	Native
102.	*Prosopis cineraria*	Khejri Tree	2	Native

103.	*Psidium guajava*	Amrud	1440	Non-Native
104.	*Pterocarpus santalinus*	Raktchandan	6	Native
105.	*Pterospermum acerifolium*	Kanakchampa	5	Native
106.	*Pterygota alata*	Buddha's Coconut	27	Native
107.	*Putranjiva roxburghii*	Putranjiva	33	Native
108.	*Ricinus communis*	Castor Oil Plant	1	Native
109.	*Sapindus mukorossi*	Reetha	93	Native
110.	*Sapindus emarginatus*	Notched Leaf Reetha	1	Native
111.	*Saraca asoca*	Sita Ashok	112	Native
112.	*Santalum album*	Indian sandalwood	2	Native
113.	*Schleichera oleosa*	Kusum	20	Native
114.	*Senna siamea*	Kassod	80	Native
115.	*Senna surattensis*	Glaucous cassia	58	Native
116.	*Sterculia foetida*	Junglee Bdam	69	Native
117.	*Swietenia macrophylla*	Big Leaf Mahagoni	39	Non-Native
118.	*Swietenia mahagoni*	Mahogani	54	Non-Native
119.	*Syzygium cumini*	Jamun	2269	Native
120.	*Syzygium salicifolium*	Paan Jambhul	53	Native
121.	*Tabernaemontana divaricata*	Chandani	13	Native
122.	*Tamarindus indica*	Tamarind	208	Native
123.	*Tectona grandis*	Teak	83	Native

124.	*Terminalia bellirica*	Beheda	144	Native
125.	*Terminalia arjuna*	Arjun	128	Native
126.	*Terminalia catappa*	Indian Badam	143	Native
127.	*Terminalia chebula*	Hirda	27	Native
128.	*Thespesia populnea*	Indian Tulip Tree	16	Native
129.	*Trema orientale*	Indian Charcoal Tree	5	Native
130.	*Vitex negundo (Black)*	Nirgundi (Black)	72	Native
131.	*Vitex negundo*	Nirgundi	115	Native
132.	*Wrightia arborea*	Tambda Kuda	38	Native
133.	*Wrightia tinctoria*	Kala Juda	52	Native
134.	*Ziziphus jujuba*	Bor	1	Native
135.	*Ziziphus rugosa*	Wild Jujube	16	Native
136.	*Unknown*[1]	-	9	Native
Total			**32,630**[2]	

Table 14. The collective species list and count of the overall plantations of CRISIL Foundation

[1] The species of 9 trees could not be identified by the plantation partner. Hence, the average carbon sequestration was calculated for these unidentified trees.

[2] For the carbon sequestration calculations, a total of 33,368 trees are considered after the addition of 424 trees from the Powai site and 314 trees from the Jogeshwari site. The details are mentioned in the site-specific sections.

5.3. Carbon Sequestration Results

Carbon Sequestration is a process of capturing and long-term storage of the atmospheric carbon dioxide in plants, soil, oceans, and geological formations. It is also one of the mitigating measures against climate change. Trees capture carbon dioxide through the process of photosynthesis and store the carbon in their biomass (trunk, branches, leaves, roots).

As the trees grow, their carbon sequestration potential increases with age. Every species of a tree has a different carbon sequestration potential depending on its biomass. The big, woody trees have a higher sequestration potential compared to the shrubs and herbs. Therefore, the carbon sequestration potential of a plantation is dependent on the diversity of the species planted, the age of the plantation, and their survival rate.

For CRISIL's plantation across the ten sites with **33,368 total surviving trees**, the total carbon sequestration potential is calculated to be **8,646.29 MTCO$_2$**. This amount of carbon sequestration will be achieved once the trees attain 15 years of age.

Chart no. 2. displays the percentage-wise distribution of the carbon sequestration potential across the different plantation sites of CRISIL Foundation.

The plantation site that contributed to the major share of the overall carbon sequestration value is **Titwala**. Being the largest plantation site with **23,958** trees on-site, it contributes a significant **73%** of the overall carbon sequestration potential.

The next highest contribution to the carbon sequestration potential is by the plantation sites of **Sanjay Gandhi National Park** (SGNP) and **Ambrosia Garden, Powai** with **5%**

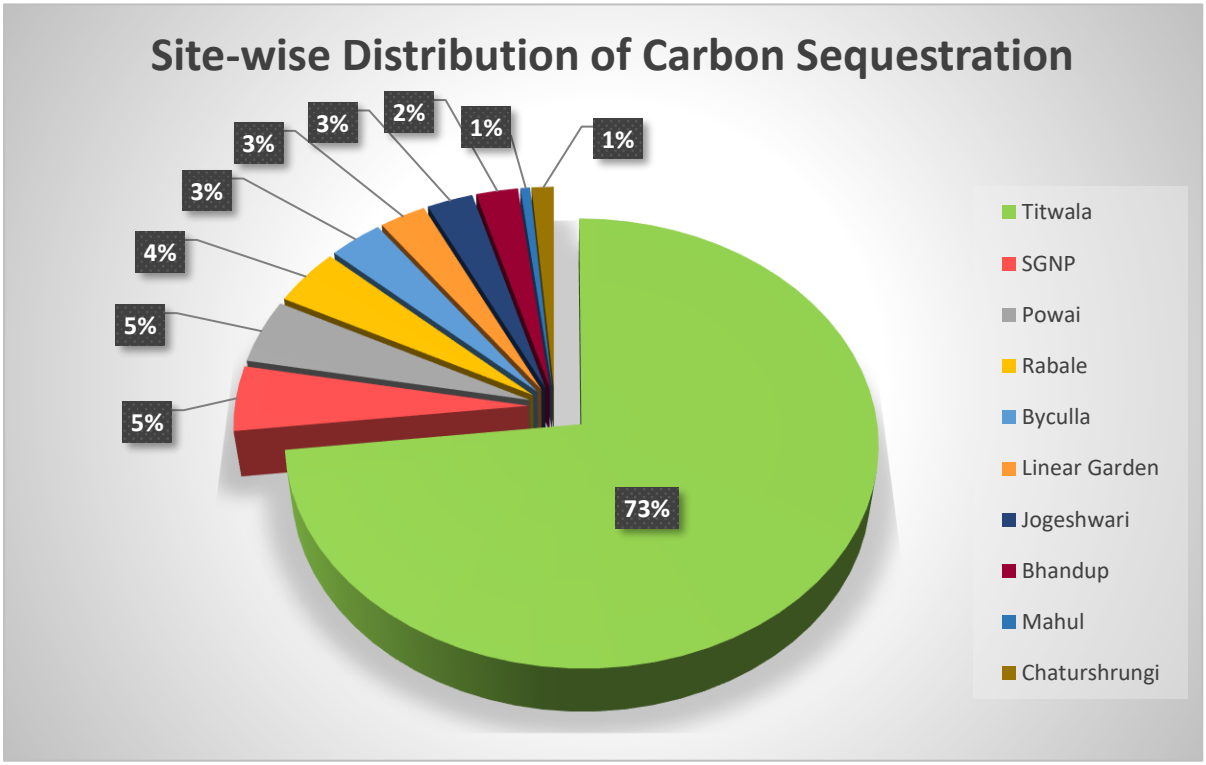


Chart 2. Percentage wise distribution of the Carbon Sequestration Potential Of Different Plantation Sites

of the total value. The number of trees found at the SGNP and Powai sites was **1,761** and **1,546** respectively.

The above two sites were followed by the **Rabale** plantation site of 1,000 plants which contributes **4%** of the total carbon dioxide sequestration. The site also had 100% survival rate of the plantation.

The plantation sites at **Byculla, Linear Garden,** and **Jogeshwari** shares **3%** of the contribution to total sequestration potential. The three sites have **1,197**, **970** and **1,256** trees respectively.

The **Bhandup** plantation site contributed **2%** with **1,000** planted at the site. This site too had a 100% survival rate of the plantation. Lastly, the plantation sites at **Chaturshrungi** and **Mahul** contributed **1%** each, to the overall carbon sequestration potential of the total plantation of CRISIL Foundation. The Mahul site has **180** trees present on the site, while Chaturshrungi has a plantation of **500** trees.

The following is the list of the individual carbon sequestration values of the different plantation sites:

S. No.	Location of Plantation	Carbon Sequestration Value ($MTCO_2$) over 15 years
1.	Rayta Village, Titwala	6328.01
2.	Sanjay Gandhi National Park	408.58
3.	Ambrosia Garden, Powai	402.62
4.	Tetavali Village, Rabale	361.11
5.	Byculla Zoo	280.31
6.	Linear Garden	242.88
7.	CRWC, Jogeshwari	239.76
8.	Water Filtration Plant, Bhandup	217.88
9.	Chaturshrungi Hills	114.80
10.	Police Dumping Ground, Mahul	50.33
Total		**8646.29**

Table 15. Carbon Sequestration Potential of individual plantation sites

6. RECOMMENDATIONS

i. Numbering each plant is recommended to help ground staff manage better and to keep a track of sapling's species. It can also be helpful in the replacement of plants in case of mortality. It can be done by physically tagging the trees with permanent tags.

ii. The plantation of invasive species should be avoided. Invasive species are dominant in nature and hinder the growth of the native species around them. Also, they are less supportive of the local fauna such as bees and butterflies, compared to the native plants' species which create an overall habitat for many birds, animals, and insects.

iii. The plantation sites should be selected by studying soil type, topography, nearby flora, water availability, site accessibility, etc. The sites with issues like waterlogging, encroachments, waste dumping, bad soil quality, etc, should be avoided. Fencing can be done if possible at the site.

iv. During plantation, the selection of plant species and their compatibility with each other should be studied and plantation should be done accordingly, to improve and ensure a good survival rate.

v. Miyawaki plantations should also incorporate herbs, shrubs, sub-trees in a designed scientific stratification that provides enough resources to improve the survival rate. Since Miyawaki is a dense plantation technique, multiple pathways should be created to access the whole site. This helps in better understanding the mortality if any.

vi. Plantation of bamboo should be avoided in Miyawaki plantation, as Bamboo has a high growth rate, and eventually, they take over the nearby plant species resulting in mortality in the plantation. The surrounding small trees get covered by a Bamboo patch and due to lack of sunlight and insufficient space for roots to spread, the plants die.

vii. Halo-effect from the pre-existing tall trees should be considered during plantation and monitored periodically to avoid future mortality of the young saplings.

viii. It is recommended to ensure that all plants have a support stick to avoid any damage in the initial stage of the plantation. Lack of support can lead to damage and even mortality in young planted saplings.

7. CONCLUSION

In today's world, climate change has become a massive threat to our survival, and carbon emissions are increasing to a new high every day. The rise in population is leading to the urbanization of more and more land, deforestation as well as an increase in pollution. In such a scenario, urban afforestation plays an important role in creating the green spaces in our cities that work as the carbon sequestration sinks and helps to improve and maintain a healthy urban ecosystem.

To support this cause, many organizations are taking up the initiative to conduct the afforestation drives as part of their CSR mandates, to protect the environment by increasing the green cover in cities.

CRISIL Foundation has been supporting such plantation drives in the cities for many years. During the years 2019, 2020, and 2021, CRISIL Foundation planted a total of **39,680 trees** across the two cities of India out of which **33,368 trees** are currently surviving, which will help to sequester **8646.29 MTCO$_2$** over a span of 15 years. The amount of carbon sequestered will help CRISIL Foundation to offset some part of the carbon emissions that resulted through their business operations and activities.

Also, through this afforestation drive, CRISIL has helped to create several habitats for the urban biodiversity such as birds, insects, small mammals, and reptiles. It has promoted the native trees species of India by planting 135 different species. Also, the plantation activities and their maintenance provided a source of livelihood to many people of local communities.

8. Carbon Sequestration Certificate presented to the Crisil Foundation

9. REFERENCES

1. Lal R. Carbon sequestration. Vol. 363, Philosophical Transactions of the Royal Society B: Biological Sciences. Royal Society; 2008. p. 815–30.

2. Christian Toochi E. Carbon sequestration: how much can forestry sequester CO2? 2018 [cited 2020 Apr 12]; Available from: http://medcraveonline.com

3. India - Countries & Regions - IEA [Internet]. [cited 2020 Apr 12]. Available from: https://www.iea.org/countries/india

4. Mani M, Bandyopadhyay S, Chonabayashi S, Markandya A, Mosier T. South Asia's Hotspots: The Impact of Temperature and Precipitation Changes on Living Standards. South Asia's Hotspots: The Impact of Temperature and Precipitation Changes on Living Standards. The World Bank; 2018.

5. Tiwari R. Issue 1 • 1000131 J Earth Sci Climate Change ISSN:2157-7617 JESCC, an open-access journal Research Article Open Access Murthy et al. J Earth Sci Clim Chang [Internet]. 2013 [cited 2020 Apr 8];4:1. Available from: http://dx.doi.org/10.4172/2157-7617.1000131