A Report on

Monitoring and Evaluation of Plantations raised under Non-CAMPA

Submitted to

Government of National Capital Territory of Delhi
(Department of Forests & Wildlife)
Vikas Bhawan
New Delhi-110002

By

Silviculture & Forest Management Division
FOREST RESEARCH INSTITUTE
P.O. New Forest
Dehradun-248006

FORWORD

Department of Forests and Wildlife, National Capital Territory of Delhi has taken up plantations under “Greening Delhi Mission” or it may also be so called as non-CAMPA plantations in the years of 2016-17, 2017-18 and 2018-19 in all forest divisions to cover all types of vacant lands in Delhi. To promote the tree plantation activity as a mass campaign and to encourage participation of Residential Welfare Associations, Civil Society, Government organizations, educational institutions etc, the Government of NCT of Delhi, carries out the 'Green Action Plan' every year. The massive plantation programme not only increasing forest cover of Delhi but also mitigates climate change impact in the Metro. Under this programme, Delhi Forest department has undertaken plantations of indigenous species which are suitable for local environmental conditions and useful for local people and wildlife. The plantations have covered a total area of 306.60 ha in 3 forest divisions of Delhi. Maximum area of plantations was covered by South Forest Division.

The Government of NCT, Delhi entrusted the Forest Research Institute (FRI), Dehradun to take up the auditing of Non –CAMPA plantations undertaken by three forest divisions. The monitoring of plantations was carried out in 2021 by the teams of FRI. The survival of plants was varied from 72% to 81%. The native species were found selected for the plantations. The native species will be helpful to increase the biodiversity of the areas. The growth of plants is found to be satisfactory but none of the plants have reached to the tree level. Encouragement of large scale afforestation as envisaged under Delhi Non- CAMPA as a part of Greening Delhi Mission (GDM) will definitely improve ecology, ameliorate environment and augment the livelihood of the people. I congratulate teams from FRI in carrying out field survey in all the plantation’s sites of Delhi during the time of Covid outbreak.

(A.S. Rawat)

PREFACE

The purpose of plantation in Delhi is to cover at least 15% of the total geographical area of Delhi under forest cover. The Government of Delhi has started plantation drive under "Greening Delhi Mission" (GDM) which is a non-CAMPA plantation programme to fulfil the above objective. The Ridge of Delhi contained maximum area under forest. At one time the Ridge was continuous, but due to developmental expansion of the city and anthropogenic pressures, the continuity of the Ridge got wiped out intermittently. It is now fragmented into South, Central and North Ridge. Under "Greening Delhi Mission" Government of NCT of Delhi has taken up plantations on available vacant lands in three forest divisions. The plantation has been started since 2016-17 and the programme is continued. It is encouraging that this plantation programme has proved the importance of the potent capacities of different species in ameliorating degraded sites and Yamuna bank which were hitherto left fallow. The plants will act as bio-remedial agents which will be proved in controlling water pollution and sewerage of Yamuna banks. The plantation will improve forest biomass and sequesters carbon from the environment and thereby will help in mitigation of climate change.

The teams from Silviculture and Forest Management Division of Forest Research Institute, Dehradun carried out monitoring and evaluation of plantations for the years 2016-17, 2017-18 and 2018-19. Monitoring of plantations was carried out in 50 percent of the plantation sites. Ten percent of the plantation area of each site was sampled for the survey. All the plantation's sites were surveyed by the teams and their boundaries were marked in GPS for area verification and for preparation of GIS maps. The maximum survival of plants was observed in Shahdra range of North Delhi forest division (81.21%) and the minimum was found in Mahrauli-II of South Delhi Forest Division (72.60%). The plantation was also done in Asola Bhatti Wildlife Sanctuary. The plantation was carried out by Eco-Task Force in South Division.

The strategy and plantation techniques and sites selected for taking up plantation in majority of the incidences were suitable for plantation. However, from the process efficiency perspective it was noticed that for carrying out cultural operations in the plantations more funds are required which may be provided regularly up to establishment of plants. The plantation survival data also reveals that about 60-70% of the plantation sites were classified as excellent to good in terms of survival. However there were about 5% sites which were classified as poor.

(R.P. Singh)

PROJECT IMPLEMENTING GROUP

DELHI FOREST DEPARTMENT

1. Sh. Ishwar Singh, IFS, Principal Chief Conservator of Forest, Govt. of NCT Delhi
2. Smt. Kamal Preet, IFS, Chief Conservator of Forest, Govt. of NCT Delhi
3. Dr. Surabhi Rai, IFS, Conservator of Forest, Govt. of NCT Delhi

FOREST RESEARCH INSTITUTE, DEHRADUN

1. Chief Project Coordinator: Sh. A.S. Rawat, IFS, D.G. ICFRE, Director FRI
2. Coordinator: Sh.R.P.Singh, IFS, Head, Silviculture and Forest Manageme -nt Division, FRI
3. Project Investigator: Sh.Sushant Kumar,IFS, Assistant Silviculturist (G), FRI

REPORT PREPARATION, COMPILATION AND DESIGNING

1. Sh. Vedpal Singh, Scientist-D
2. Sh. V.K. Dhawan, Forestry Expert
3. Sh. Mohit Husain, Scientist-B
4. Dr. Vishwajeet Sharma, Technical Officer
5. Sh. Piyush Rawat, Technician

TEAM MEMBERS

1. Sh. Lokinder Sharma, Scientist-B
2. Sh. Nalin Rawat, JRF
3. Sh. Vikas Shah, FA
4. Sh. Prateek Kumar Pal, FA
5. Sh. Sagar,FA
6. Sh. Anuj Kavi, FA
7. Sh. Ritesh Chauhan, FA
8. Sh. Ankit Siraswal,FA

Executive Summary

The State of Forest Report, 2019 has reported that Delhi has total Forest Cover of 195.44 sq km which is 13.18 % of the State's geographical area. The primary aim of Delhi Forest Department is to maintain 2-3rd of the area under such forest cover in order to prevent erosion and land degradation and to ensure stability of the fragile eco-system keeping in view of massive industrialization, urbanization and vehicular pollution. Vegetation of Delhi is typical Northern Tropical Thorn Forest Type (Champion & Seth 1968). Among trees Acacias such as *A. nilotica, A. leucophloea, A. catechu, A. Modesta* are commonly found. *Butea monosperma* (Dhak), *Cassia fistula, Salvadora persica, Anogeissus latifolia* with abundance of *Prosopis juliflora* form the major vegetation of the area. Delhi forest department has started plantations under Greening Delhi Scheme to cover all types of vacant lands with forest vegetation. The basic objectives of the scheme are:

- Increasing the forest and tree cover including protection of existing forests for and taking measures for improvement of the soil/moisture regime quality as green lung for the Metro.
- Publishing of brochures/statistics, various documents related to action plans formulated by Delhi Govt. for dissemination of information to the public.
- Enforcement of Indian Forest Act, 1927 and DPTA, 1994 and Wildlife Protection Act, 1972 and Forest Conservation Act, 1980.
- Monitoring and Evaluation of plantations.

The Delhi Forest department encourages large scale afforestation as envisaged under Delhi Non- CAMPA as a part of Greening Delhi Mission (GDM) to improve ecology, ameliorate environment and augment the livelihood of the people. The task of plantation is enormous and it requires proper monitoring and evaluation so as to successfully achieve the objectives of the project. Monitoring and evaluation will help the policy planers for correct decision making and future management. It is a process that involves on-going and routine collection of information used to assess the efficient use of resources and the extent to which the programme has achieved its objectives in terms of outputs (programme activities) and outcomes and impact (whether the expected benefits to the target population were reached). Monitoring and evaluation of the project is done to know status and the impact of the plantations. Hence, the Government of NCT, Delhi entrusted the Forest Research Institute

(FRI), Dehradun to take up the auditing of Non-CAMPA plantations of 2016-17, 2017-18 and 2018-19 in all forest divisions of Delhi Forest Department.

For carrying out monitoring of plantations, 50 percent of the plantation sites and 10 percent of the plantation area was sampled for the survey. However, all sites were surveyed for area verification with GPS. The overall survival percentage of the plantations for three years varied from 3 divisions within a range from 72% to 81% in the state. The maximum survival of plants was observed in Shahdra range of North Delhi forest division (81.21%) and the minimum was found in Mahrauli-II of South Delhi Forest Division (72.60%). The growth of plants is found to be satisfactory but none of the plants have reached to tree level.

During the monitoring of plantations no serious and specific symptoms of damages by insects and pests have been recorded. The cultural operations like singling, weeding, pruning, watering, soil working etc. could not have been taken up in most of the plantations properly as per prescriptions. The growth of plants would have improved if the plantations might have been protected from wild and stray animals and cultural operations could have been carried out timely. The major species planted in the years were *Terminalia arjuna, Melia azedarach, Dalbergia sissoo, Albizia lebbeck, Morus alba, Bauhinia variegata, Acacia catechu, Holoptelea integrifolia, Phyllanthus emblica, Acacia nilotica, Albizia procera,Terminalia chebula,Terminalia bellerica, Pterospermum acrifolium, syzygium cumini, Ficus benghalensis* etc. It is imperative that sites of the plantations and species should be selected keeping in view of ecology of sites and biotic factors. The protection and maintenance period should be varied for the different sites as per the site conditions.

It is encouraging that this plantation programme has proved the importance of the potent capacities of different species in ameliorating degraded sites and Yamuna bank sites which were hitherto left fallow. This result would definitely persuade others to think for the bioremediation of large tracts adversely affected due to inflow of industrial polluted water and sewerage in Delhi. The presence of varieties of other local species and an array of visiting avifauna ensures a lasting hope for bringing back the natural renewability of the unutilized land in addition to enhancing the green canopy over the area. The plantation will improve forest biomass and sequesters carbon from the environment and thereby will help in mitigation of climate change.

The Division wise overall performance of the average weighted survival of different sites in 3 forest divisions of Delhi is given below. The field survey was carried out in March 2021.

Division wise status of Survival Percentage of Non-CAMPA plantations for the years 2016-17, 2017-18 and 2018-19

Sl. no.	Forest Divisions	Forest Range	Years	Survival %
1.	North	Shahdara	2016-17, 2017-18 & 2018-19	80.21
2.	West	Alipur	2016-17, 2017-18 & 2018-19	78.50
		Najafgarh	2016-17, 2017-18 & 2018-19	75.68
3.	South	Mahrauli-II	2018-19	72.60
		Asola Bhatti	2018-19	76.20
		Eco-task Force	2018-19	81.33

1.0 Introduction:

Delhi state stretches along the western bank of the Yamuna river between 28^{o} 12’ and 28^{o} 53’ north latitude and 76^{o} 50’ and 77^{o} 23’ east longitude. It is surrounded on the south-east by Thar Desert, on the north-east by the Indo-Gangetic plains and in the south by the Aravallis. Due to its location, the State, which is 58.3 km in length and 48 km in width, has a diversity of physiographic features as well as vegetation.

According to State of Forest Report, 2019, Delhi has total Forest Cover of 195.44 sq km which is 13.18 % of the State's geographical area. In terms of forest canopy density classes, the State has 6.72 sq km under Very Dense Forest (VDF), 56.42 sq km under Moderately Dense Forest (MDF) and 132.30 sq km under Open Forest (OF). Forest Cover in the State has increased by 3.03 sq km as compared to the previous assessment reported in ISFR 2017. The Forest Cover includes recorded forest area of 102 sq. km and 93.44 sq km under plantations. The Recorded Forest Area (RFA) in the State is 102 sq km of which 78 sq km is Reserved Forest and 24 sq km is Protected Forest. In Delhi, no forest land has been diverted for non-forestry purposes under the Forest Conservation Act, 1980 in the last four years (MoEF& CC, 2019).

As per the Champion & Seth Classification of Forest Types (1968), the forests in Delhi belong to the Type Group 5, Tropical Dry Deciduous Forest and Type Group 6 Tropical Thorn Forests. Around 67.35% of the total forest cover comes under plantation/ TOF and 32.65% constitute the natural forest, which covers 57.67 sq km of Delhi's forests. Forest department under the Government of Delhi supervises and monitors various activities such as distribution of seedlings to public, government departments and institutions, plantations on gram sabha lands, along the roads, ridge area, river banks, railway lines etc. To promote the tree plantation activity as a mass campaign and to encourage participation of Residential Welfare Associations, Civil Society, Government organizations, educational institutions etc, the Government of NCT of Delhi, carries out the 'Green Action Plan' every year.

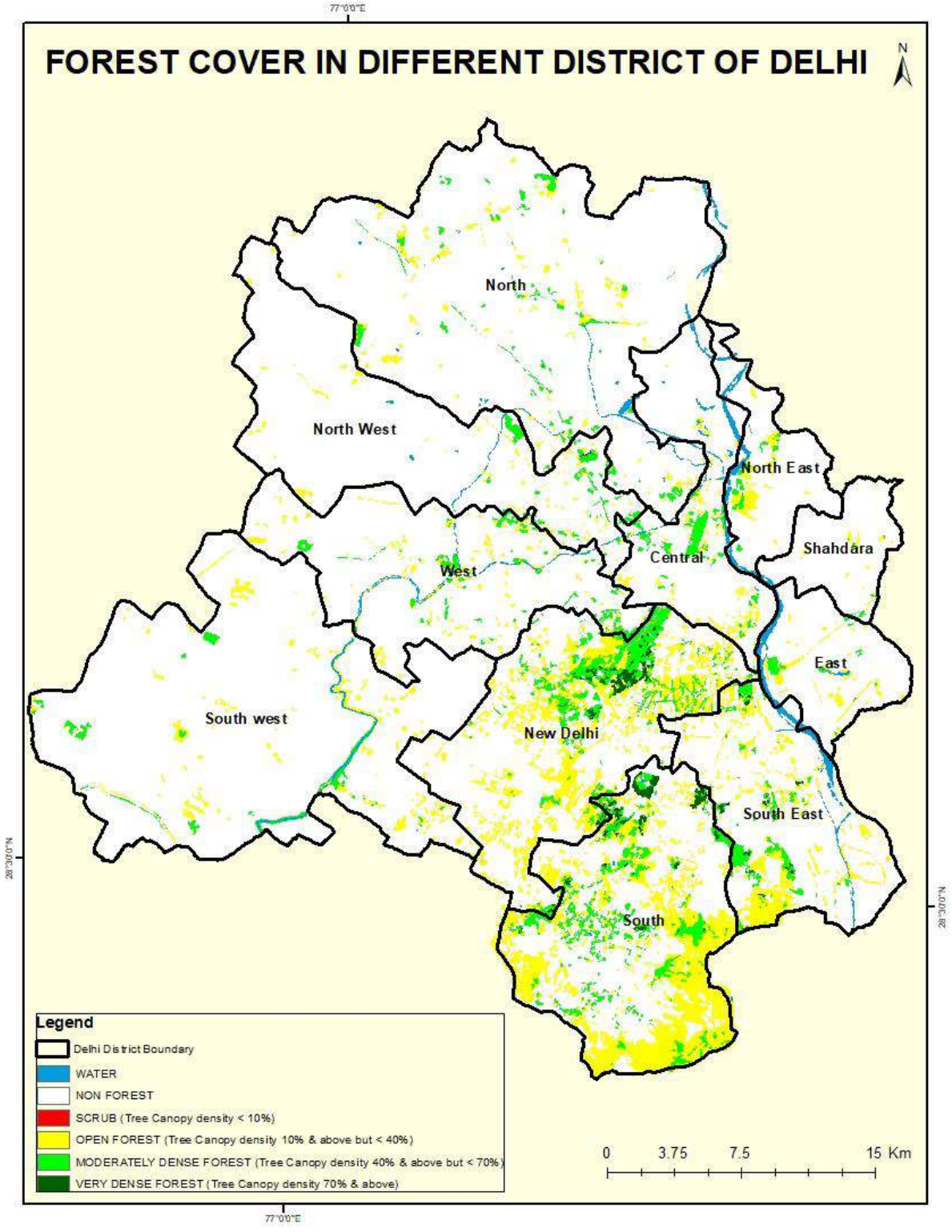


Figure 1.0: Map of Forest Cover of Delhi

The 32 km long Delhi ridge is an inseparable part of Delhi City. The Ridge has played an important role in Delhi's history, and will continue to do so. The forest of Delhi is being

maintained for the environmental and ecosystem services being imparted by these forests, production forestry is not the major objective of management of these forests. The ridge serves many valuable ecological functions, protecting Delhi from westerly winds loaded with sand from desert areas of Rajasthan, lowering the ambient temperature, pollution absorption, cleaning the air, sheltering flora and fauna, and – perhaps most importantly – filtering and preserving groundwater in a parched city.

There is a possibility that the Ridge at one time was continuous, but due to developmental expansion of the city and anthropogenic pressures, the continuity of the Ridge got wiped out intermittently. Today, it comprises of five fragmented zones namely, Northern Ridge, Central Ridge, South Central Ridge, Southern Ridge and Nanakpura South Central Ridge. The Northern Ridge (also called Old Delhi) comprises of the hilly area near Delhi University. It is approximately 87 hectares. The Central Ridge (also called New Delhi) consists of around 864 hectares of forested area, from south of Sadar Bazaar to Dhaula Kuan, but some bits of the Central Ridge have been nibbled away. The South-Central Ridge (also called Mehrauli) consists of 626 Hectares of forested land around the Sanjay Vana area, near Jawaharlal Nehru University (JNU). The Southern Ridge (also called Tughlaqabad) consisting of 6200 hectares is the biggest area of the Delhi Ridge. The Nanakpura South Central Ridge has an area of 7 hectares. All the 5 Zones make up for a total area of 7,784 hectares spread over the entire city in different patches.

1.1 Non –CAMPA Plantation:

The Government of NCT of Delhi carries out the 'Green Action Plan', organized every year by the Forest department. Forest department of Delhi undertakes massive plantations on all vacant and degraded areas on gram sabha lands, along the roads, ridge areas, river banks, railway lines etc. The objectives are:

(i) To promote the tree plantation activity as a mass campaign and to encourage participation of Residential Welfare Associations, Civil Society, Government organizations, educational institutions etc,.

(ii) To mitigate air pollution by planting species suitable for trapping maximum air and water pollution of Delhi.

(iii) To increase forest cover of NCT Delhi and to develop forest ecosystem.

(iv) To increase biodiversity by planting of indigenous species.

Under this programme, Delhi Forest department has undertaken plantations of indigenous species which are suitable for local environmental conditions and useful for local people and wildlife.

The task of plantation is enormous and it requires proper monitoring and evaluation so as to successfully achieve the objectives of the scheme. Monitoring and evaluation will help the policy planers for decision making and future management. It is a process that involves on-going and routine collection of information used to assess the efficient use of resources and the extent to which the programme has achieved its objectives in terms of outputs (programme activities) and outcomes and impact (whether the expected benefits to the target population were reached). Monitoring and evaluation of the project is done to know status and the impact of the plantation.

Hence, the Government of NCT, Delhi entrusted the Forest Research Institute (FRI), Dehradun to take up the concurrent monitoring and evaluation of NON-CAMPA plantations for 2016-17, 2017-18 and 2018-19 in all forest divisions of Delhi.

1.2 Study Sites and Evaluation Process

1.2.1 Study Sites

The monitoring and evaluation works of plantations under Non-CAMPA (2016-17, 2017-18 and 2018-19) were carried out by Forest Research Institute, Dehradun in the month of March 2021. The data was collected from 3 forest divisions i.e. north, south and west. Central division of Delhi has recently been carved out from some areas of south and west forest divisions. Therefore, the plantation sites of Central division were covered under erstwhile two divisions. Total 49 sample sites out of total 25 sites were selected randomly. Plantation area of 184.10 ha out of total area of 306.60 ha was selected in the present study for monitoring and evaluation (table 1.0). The details of the sites selected for monitoring of the plantations under the program viz., NON-CAMPA in all the divisions of Delhi is provided in Table no. 1.0

Table 1.1: NON-CAMPA sampled sites and area undertaken for monitoring

Sr. No.	Name of Division	Year of Plantation	Sites covered	Total Sites	Area Covered (ha)	Total area of plantation (ha) as sent by DFD
1	North	2016-17, 2017-18 & 2018-19	5	9	60.25	113.62
2	South	2018-19	6	12	87.50	146.57
3	West	2016-17, 2017-18 & 2018-19	14	28	36.35	46.41
		Total	**25**	**49**	**184.10**	**306.60**

1.2.2 Evaluation and Process

1.2.2.1 Methodology:

Monitoring and evaluation works under NON- CAMPA scheme has been carried out by selecting sample plots in selected sites of forest range. Moreover, the size of plots and category of plantations were also taken into consideration for representation of all units. The random sampling strategy was adopted for the selection of sample plots in all study sites of the forest ranges. The selected plantation sites were traversed and area of the plantations was verified by recording the GPS locations. GPS points of each sample plot of the sites are recorded and presented in the annexure. About fifty percent of the sites were selected for monitoring of the total plantation sites and 10% of the plantation's area of each sample site was selected for data collection. However, more than 10% area was also selected depending on the sample size. In each patch up to size of 5 ha, five sample plot of 0.1 ha was laid, in patch of 10 ha, ten plots of 0.1 ha were laid, in case of patch with area 15 ha, 15 samples plots, and for 20 ha size patch a total of 20 sample plots were laid for monitoring. If the plantation is carried out in rows or strips along the roads or canals, a row of 100 m length of plantation was treated as a one sample plot. The configuration and dimension of plots therefore change as per the site location.

The sample plots were randomly selected as follows:

1. The sample plots were proportionately allocated into each division so as to cover the scheme and its components.
2. Selected plantation area or site was examined for area accuracy with the help of GPS by way of traversing around the boundary of the plantation.

3. Within the plantation patches plots of 0.1 hectare size 31.62 m x 31.62 m were laid in rectangular or square shape as per field convenience to assess survival and growth parameters of plants as per format.
4. In small plantation area up to 5 hectares, five plots of size 0.1 hectare were laid at designated places.
5. In selected area of 10 ha, 10 plots were laid out at designated places. The selection of 2nd patch was randomized to avoid biasness.
6. For plots of 20 ha, 20 plots were laid out at designated places. The selection of patches was randomized to avoid biasness.
7. If the plantation is carried out in rows or strips along the roads or canals, a row of 100 m length of plantation was treated as a one sample plot.

1.2.2.2. Indicators for Monitoring and Evaluation:

The indicators were simple, measurable yardsticks for assessing the plantations in terms of their effectiveness, relevance and sustainability. These indicators were finalized in accordance with the needs for output, outcome and impacts of the scheme at the plantation sites with respect to biodiversity conservation. By using these indicators, the information pertaining to various parameters such as plantation scheme, species selection, plantation methodology, health of plantations, survival rate and other was generated during the field sampling in the sampled plantation patches.

The major Indicators for data collection are provided below:

1. Choice of species for the sites
2. Selection of the planting site
3. Planting methods
4. Size of the pits/trenches including earth work done
5. Spacing of the pits
6. Time of planting
7. Health of the plants (insect-pests & diseases or other causes)
8. Cultural operations (Hoeing, weeding, soil working etc.)
9. Protection measures
10. Management of plantations (causality replacement, watering, pruning, thinning etc.)
11. Growth and survival of plants
12. Soil and Water Conservation measures

1.2.2.3. Collection of field data

The parameters used for assessing the plantation works were choice of species with respect to the requirement of sites, local communities need/perception about the species, readiness of planting such as cleaning and preparation of sites, advance pitting for proper weathering, temporary arrangement for storage of seedlings and arrangement for irrigation before planting, soil working and weeding immediately after planting and causality replacement of plant if required. In addition to above the ecological aspects such as soil and water conservation activities undertaken under the scheme in different plantations sites were also observed to understand their impact at these sites. Efforts were also made to understand the socio-economic issues in terms of fuel and fodder supply and improvement in water table by interacting with local people. Biodiversity aspect of the plantation activities was also recorded by conducting vegetation analysis in plantation sites and presence of wild fauna during the survey. The data for the monitoring and evaluation of the plantation sites was collected by a multidisciplinary team with experts from disciplines such as Silviculture, Ecology, Soil science etc. as per requirement of the site. The collected data was compiled, tabulated and then analyzed for the preparation of the final report.

1. 2.2.4. Compilation and analysis of field data

The data collected from the teams of FRI were compiled and tabulated. The field data of each site was compiled range wise. The survival of plants was calculated by using data on number of plants of each species planted from the plantation's records to the actual number of plants observed in the fields. The average height and diameter of each species is also compiled for observation of growth of plants.

1.3. Performance Assessment

1.3.1 Relevance

The investment in the plantation and afforestation activities in Delhi under 'Greening Mission of Delhi' is both relevant to and consistent with the policies and plans of the state and central government. The central and state government viewed plantation activities as critically important for the restoration of degraded lands, biodiversity conservation, increasing green cover and also a source of employment and income for a large segment of the population. The scheme 'Green Action Plan' provided a long-term finance for investment for the plantation activities which was not readily available from other sources. The project is very much relevant to the mission and vision of the Delhi State Forest Policy as its implementation was likely to result in enhancement of forest cover, improvement of quality of existing forested areas, biodiversity conservation, rehabilitation of degraded lands and livelihood generation for the local communities.

1.3.2. Effectiveness

The project outputs and outcomes and their actual achievements are shown in the following divisional reports. The reports were prepared based on the collection of primary data collected during the field surveys in all selected sites distributed in different forest divisions, where plantations were carried out under Non-CAPMA. The primary data was collected in a well prepared format. Twenty seven (27) different plant species were found planted in all the sites (Tables 1.2). The soil and water conservation activities were not quite evident since there were few sites where soil and water conservation activities were carried out.

Table 1.2: Species planted under Non-CAMPA

Sl. No	Botanical Name	Local Name
1.	*Acacia catechu*	Khair
2.	*Acacia nilotica*	Kikar
3.	*Albizia lebbek*	Siras
4.	*Albizia procera*	Siras safed
5.	*Anthocephalus chinensis*	Kadam
6.	*Azadirachta indica*	Neem
7.	*Bauhinia variegata*	Kachnar
8.	*Bombax cieba*	Semal
9.	*Callistemon viminalis*	Bottle brush
10.	*Cassia fistula*	Amaltas
11.	*Cassia siamea*	Kassod
12.	*Dalbergia sissoo*	Tali, Shisham
13.	*Eugenia jambolana*	Jamun
14.	*Ficus benghalensis*	Bargad
15.	*Ficus religiosa*	Pipal
16.	*Ficus infectoria*	Pilkhan
17.	*Holoptelea integrifolia*	Papdi
18.	*Melia azedarach*	Baken
19.	*Morus alba*	Toot
20.	*Nerium oleander*	Kaner
21.	*Emblica officinalis*	Amla
22.	*Pithecellobium dulce*	Jangle jalebi
23.	*Pterospermum acerifolium*	Kanak Champa
24.	*Terminalia arjuna*	Arjan
25.	*Terminalia chebula*	Harad
26.	*Terminalia bellerica*	Baheda
27.	*Thevetia peruviana*	Pili Kaner

1.3.3 Survival of plantations

Range wise average survival percentages of plants are shown in figure 1.1 below revealed that maximum survival (80%) was calculated in Shahdra range followed by Eco-task force (81.33%), Alipur (78.50%), Asola Bhatti (76.20%), Najafgarh (75.68%), , and Mahrauli-II (72.60%) ranges in descending order.

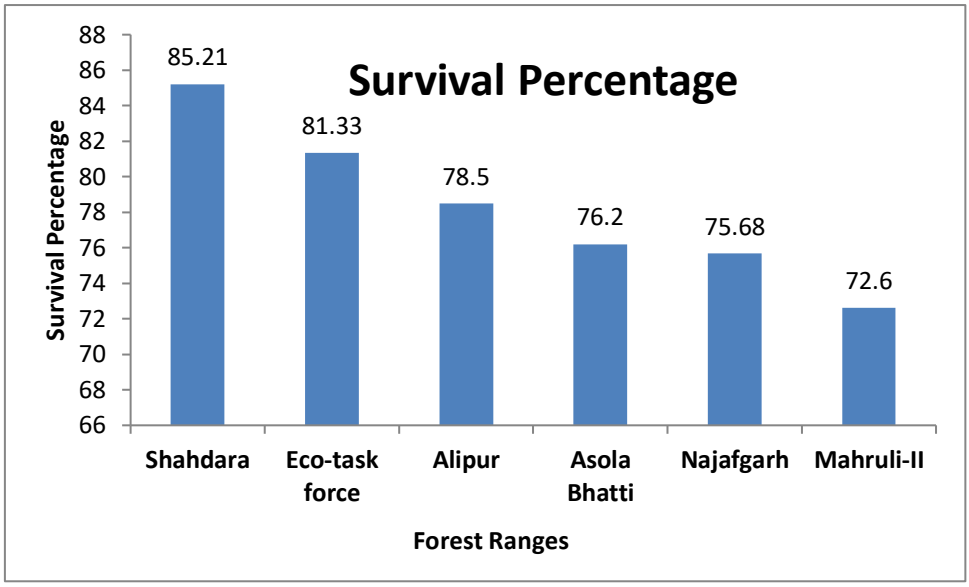


Figure 1.1 Range wise Survival Percentages of plants under Non-CAMPA

1.3.4 Overall Assessment

The field data collected under the present plantation monitoring study indicates that plantation scheme will be of significant importance in achieving the goal of Delhi Forest Department to increase green cover in the state. The strategy and plantation techniques and sites selected for taking up plantation in majority of the incidences were suitable for plantation. However, from the process efficiency perspective it was noticed that for carrying out cultural operations in the plantations more funds are required which may be provided regularly up to establishment of plants. The plantation survival data also reveals that about 60-70% of the plantation sites were classified as excellent to good in terms of survival. However there were about 5% sites which were classified as poor.

1.4 Division Wise Monitoring and Evaluation

1.4.1 North Forest Division

Monitoring and evaluation of the plantations raised under NON-CAMPA for the years 2016-17, 2017-18 and 2018-19 was carried out by the team of Forest research Institute, Dehradun in March 2021. One range viz., Shahdra Range of North Forest Division has been covered in this report. The target of monitoring of 2016-17 plantations was 9.15 hectare with 1 site, for the year 2017-18 plantations was 2.0 hectare with 1 site and for the year 2018-19 plantations; the target was 49.01 hectare with 3 sites. As per sampling procedures, fifty percent of the sites were selected randomly and 10% of area was selected for data collection. GPS coordinates of each sample plot were recorded and presented in the annexure. The data collection sites, field observations, survival and growth of the plants in the forest range are given below.

Table 1.3 Sample Sites of North Forest Division under NON-CAMPA

Forest Range	Sl. No	Name of the site taken for Monitoring	Area (ha)	Plantation Year
Shahdra	1.	Yamuna flood plains near IIIrd Pushta, Usmanpur	14.65	2018-19
	2.	Yamuna flood plains near IIIrd Pushta, Usmanpur	14.45	2018-19
	3.	Yamuna flood plains, Usmanpur	20.00	2018-19
	4.	Shastri Park plantation area Near Bela Farm	9.15	2016-17
	5.	Netaji Subhash Chandra Bose Marg	2.00	2017-18

1.4.1.1. Monitoring Team:

FRI Team

1. Sh. Lokinder Sharma, Scientist-B
2. Sh. Nalin Rawat, Junior Research Fellow
3. Sh. Sagar, Field Assistant
4. Sh. Prateek Kumar Pal, Field Assistant

Shahdra Range Team

1. Sh. Suresh Kumar, Range Officer
2. Sh. Karnail Singh Sehrawat, Forest Guard

1.4.1.2 Date of Survey: 18 March, 2021

1.4.1.2 Shahdra Range

1.4.1.3 Field observations:

i. The plantation sites monitored are suitable for species i.e Kadam (*Anthocephalus chinensis*), Arjun (*Terminalia arjuna*), Baheda (*Terminalia bellerica*), Shisham (*Dalbergia sissoo*), Jamun (*Syzygium cumini*), Amaltash (*Cassia fistula*), Bargad (*Ficus beghalensis*), Pilkhan (*Ficus infectoria*), Peepal (*Ficus religiosa*), Papdi (*Holoptelea integrifolia*), Gulmohar (*Delonix regia*), Mulbery (*Morus alba*), Amla (*Emblica officinalis*), *Cassia siamea*, Semal (Bombex cieba*)*, Kachnar *(Bauhinia variegata)*, Neem *(Azadirachta indica)* and Jungle jalebi (*Pithecellobium dulce*).

ii. A total of 5 plantation sites were sampled for monitoring NON -CAMPA plantations in Shahdra range and three sites are situated near the Yamuna flood plains. Some areas of the plantation sites are under waterlogged area, although they have planted the suitable waterlogged species like, Arjun, Shisham and Jamun.

iii. Barbed wire fencing was created at Yamuna flood plains near IIIrd Pushta Usmanpur plantation site. Fencing was found very effective against the protection from animals.

iv. Plantation was done on trench -cum pit method and the spacing between row and column was 3 x 3 meter which was modified at few places due to site conditions.

v. The growth and health of the plants were found very well at all plantation sites due to drain by flood water.

vi. Watchers were also deployed for the protection and maintenance of the plantation sites.

vii. The wild animals mainly Porcupine, Neelgai and Wild boar cause damaged to plants also. However there was least biotic interference by nearby villagers.

viii. The survival of plants is calculated as 85.00%. The maximum survival (88.50%) of plants is observed in Yamuna flood plains near IIIrd Pushta Usmanpur (table 1.4).

Table 1.4 Survival percentages of plants at different sites of Shahdra Range

Sl. No.	Sample Sites	Survival %
1.	Yamuna flood plains near IIIrd Pushta Usmanpur	88.50
2.	Yamuna flood plains near IIIrd Pushta Usmanpur	83.60
3.	Yamuna Flood Plains Usmanpur	84.20
4.	Shastri Park Plantation Area Near Bela Farm	86.20
5.	Netaji Subhash Chandra Bose Marg	82.50
	Average survival	**85.00**

1.4.1.4 Heights of the Plants: Kadam, Arjun, Shisham, Jamun, Amaltash, Bargad, Pilkhan, Peepal, Gulmohar, Amala, Cassia, *Bombex cieba*, Jungle jalebi and other species were planted in the year 2018-19. Figure 1.2 shows that shisham has maximum height of 3.76 m followed by Mulberry (3.49 m), Amla (3.49 m), Amaltas (3.43 m), Jungle jalebi (3.14 m), Peepal (3.12 m) and Baheda (3.08 m).

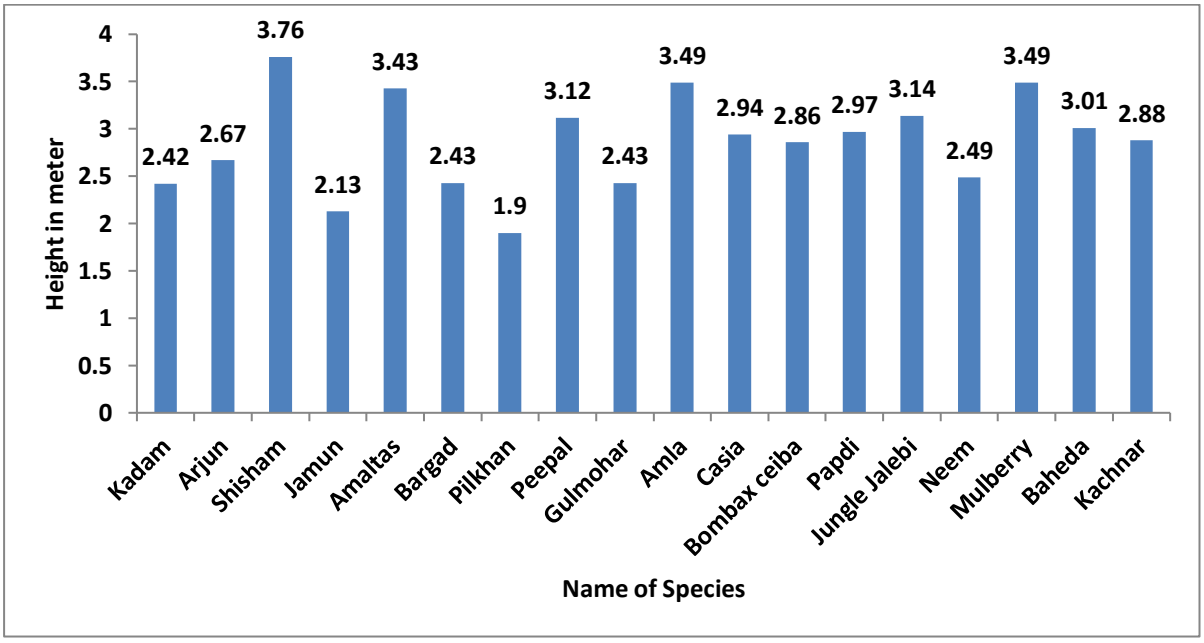


Figure 1.2 Heights of the Plants

1.4.1.5 Collar Diameters of the Plants: From the figure1.3 it was clearly observed that during the year 2018-19 the maximum average collar diameter of 6.4 cm was obtained by Amaltas followed by Shisham (6.3 cm), Bargad (5.9 cm), Mulberry (5.7 cm), Peepal (5.7 cm), Amla (5.6cm), and Arjun (5.2 cm) plants.

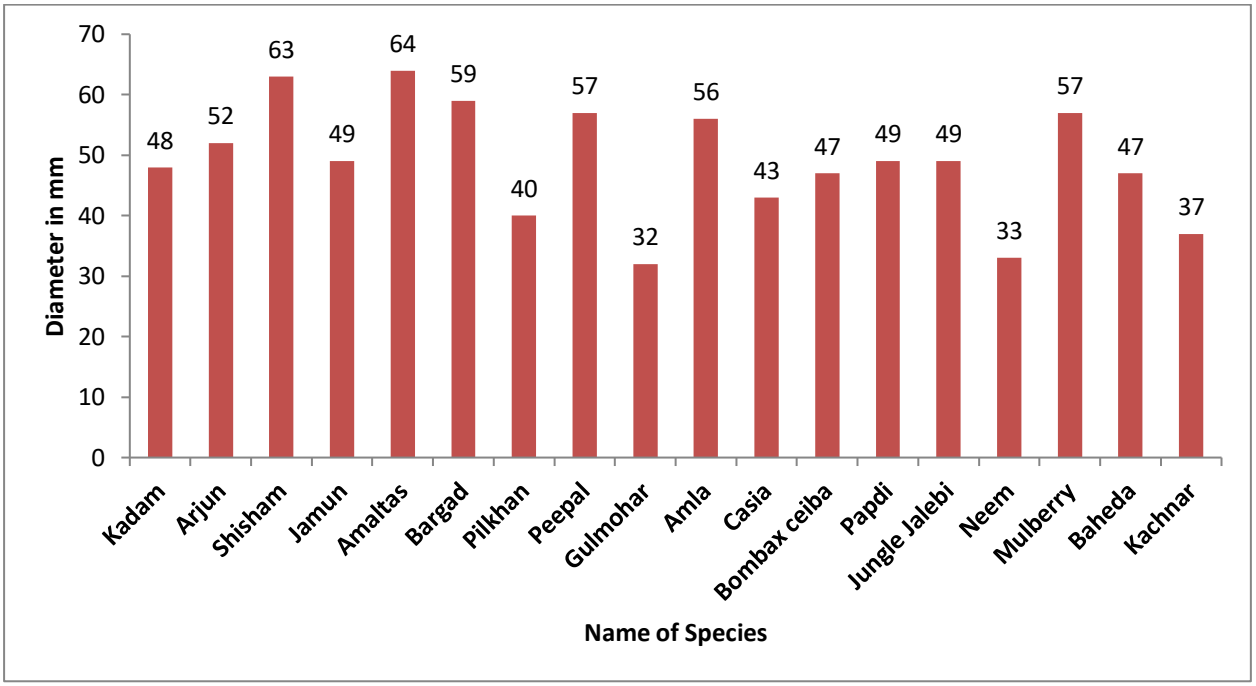


Figure 1.3 Collar Diameters of the Plants

Photos of Shahdra Range

(a)

(b)

(c)

(d)

Fig 15:(a) Laying out sample plot at Yamuna Flood Plains near IIIrd Pushta Usmanpur
(b) View of Yamuna Flood Plains near IIIrd Pushta Usmanpur plantation site
(c) Diameter measurement of plant at Yamuna Flood Plains near IIIrd Pushta Usmanpur
(d) View of Yamuna Flood Plains near IIIrd Pushta Usmanpur plantation site

(e)

(f)

(g)

(h)

Fig 15: **(e)** Height measurement of plant at Yamuna Flood Plains Usmanpur
(f) Yamuna Flood Plains Usmanpur plantation site
(g) Watering at Shastri Park Plantation Area near Bela Farm plantation
(h) Monitoring team at Netaji Subhash Chandra Bose Marg plantation

1.4.2 South Forest Division

Monitoring and evaluation of the plantations raised under NON-CAMPA for the years 2018-19 was carried out by the team of Forest research Institute, Dehradun in March 2021. A total of two ranges viz., Asola Bhatti and Mehrauli-II and also two plantation sites of Eco Task Force of South Forest Division have been covered in this report. The target of monitoring for the year 2018-19 plantations was 87.50 hectare with 6 sites. As per sampling procedures, fifty percent of the sites were selected randomly and 10% of area was selected for data collection. GPS coordinates of each sample plot were recorded and presented in the annexure. The data collection sites, field observations, survival and growth of the plants in three forest ranges are given below.

Table 1.5 Sample Sites of South Forest Division under NON-CAMPA

Forest Range	SL. No	Name of the site taken for Monitoring	Area (ha)	Plantation Year
Asola Bhatti	1.	Tughlakabad	32.50	2018-19
	2.	Asola	4.00	2018-19
	3.	Bhatti (Radha Swami)	7.20	2018-19
Mehrauli-II	4.	Dera Mandi	3.00	2018-19
Eco Task Force	5.	Asola	26.60	2018-19
	6.	Jounapur	14.20	2018-19

1.4.2.1. Monitoring Team:

FRI Team

1. Sh. Lokinder Sharma, Scientist-B
2. Sh. Nalin Rawat, Junior Research Fellow
3. Sh. Sagar, Field Assistant
4. Sh. Prateek Kumar Pal, Field Assistant

Asola Bhatti Range Team

1. Sh. Tajuddin, Deputy Range Officer
2. Sh. Rohit Nehra, Forest Guard

Mehrauli-II Range Team

1. Sh. Pardeep Lohchab, Forest Guard

Eco Task ForceTeam

1. Lieutenant Colonel Sanket, 132 Eco Task Force

1.4.2.2 Date of Survey: 19 March to 20 March, 2021

1.4.2.3 Asola Bhatti Range

1.5.2.3.1 Field observations:

i. The plantation sites monitored are suitable for species i.e Amaltash (*Cassia fistula*), Kikar (*Acacia nilotica*), Shisham (*Dalbergia sissoo*), Kadam (*Anthocephalus chinensis*), Papdi (*Holoptelea integrifolia*), Arjun (*Terminalia arjuna*), Pilkhan (*Ficus infectoria*), Siris (*Albizzia lebbeck*), Kachnar (*Bauhinia variegata*), Jamun (*Syzygium cumini*), Kanak champa (*Pterocarpus acerifolium*), Harad (*Terminalia chebula*) and Baheda (*Terminalia bellerica*).

ii. Monitoring was carried out at three plantation sites, out of which two plantations were undertaken in protected forest area of Asola Bhatti Wildlife Sanctuary.

iii. Plantation was done using trench- cum pit method and the spacing between row and column was 3x3m, which was modified at few places because of site conditions.

iv. The growth and health of all plants was found good at all plantation sites.

v. Low biotic interference and grazing incidents were observed at the plantation sites.

vi. Watchers were also deployed for the protection and maintenance of the plantation sites.

vii. Watering to the plants was provided with the help of water tankers and tube wells.

viii. The wild animals mainly Porcupine, Neelgai and Wild boar cause damaged to the plants.

ix. Plantation journals were not maintained at all the sites and there was no record of inspection by senior officers.

x. The average survival of plants in the range is 75.78%. Maximum survival of plants is found in Bhatti (Radha Swami-80.20%).

Table 1.5 Survival percentages of plants at different sites of Asola Bhatti Range

SL. No.	Sample Sites	Survival %
1.	Tughlakabad	71.50
2.	Asola	75.65
3.	Bhatti (Radha Swami)	80.20
	Average Survival	**75.78**

1.4.2.3.2 Heights of the Plants: Figure 1.4 shows that in the plantations, maximum average height of 2.10 m was obtained by Siris followed by Arjun (1.93 m), Shisham (1.89 m), Harad (1.80 m), Amaltas (1.76 m), Kachnar (1.34 m), Kadam (1.24 m), Kikar (1.16 m), Amrud (1.16 m), Baheda (1.13 m), Jamun (1.09 m) and Acacia (1.09) species in descending order. Imli has shown minimum height (0.79 m).

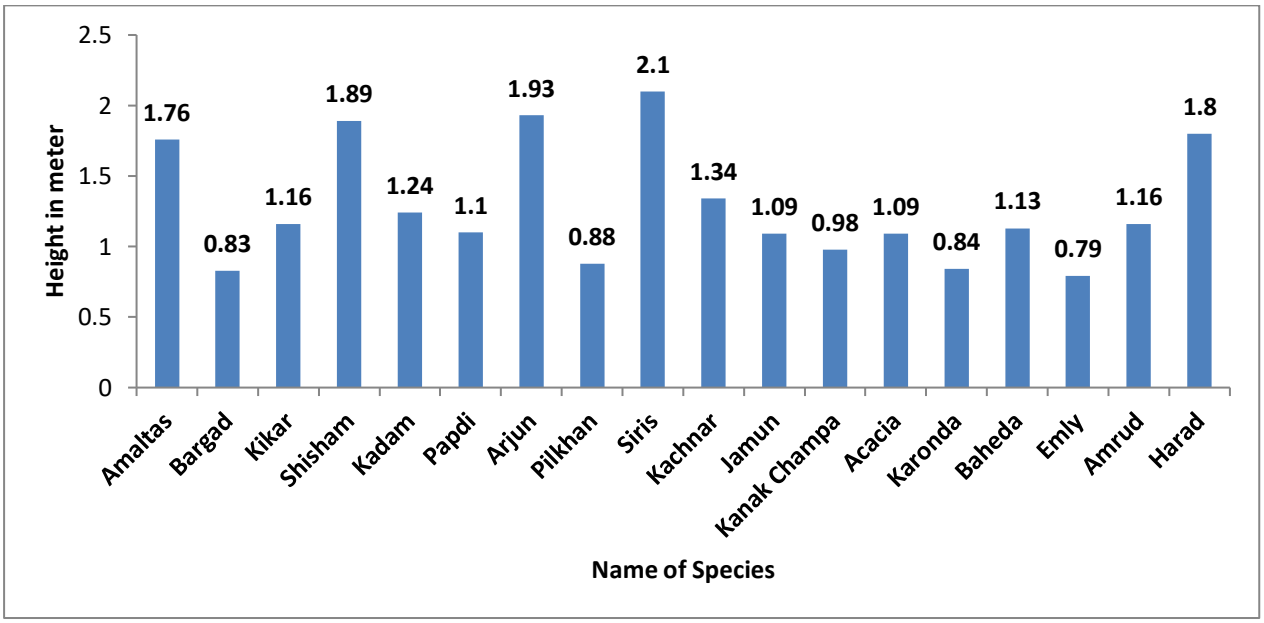


Figure 1.4 Heights of the Plants

1.4.2.3.3 Collar Diameters of the Plants: From the figure 1.5, it was clearly observed that the maximum average collar diameter of 4.6 cm was obtained by Siris followed by Kadam (4.3 cm), Kachnar (4.3 cm), Kikar (4.1 cm), Amrud (4.1 cm), Harad (3.7 cm), Acacia (3.7 cm), Jamun (3.7 cm), Shisham (3.7 cm), Baheda (3.6 cm), Amaltas (3.6) and Arjun (3.5 cm).

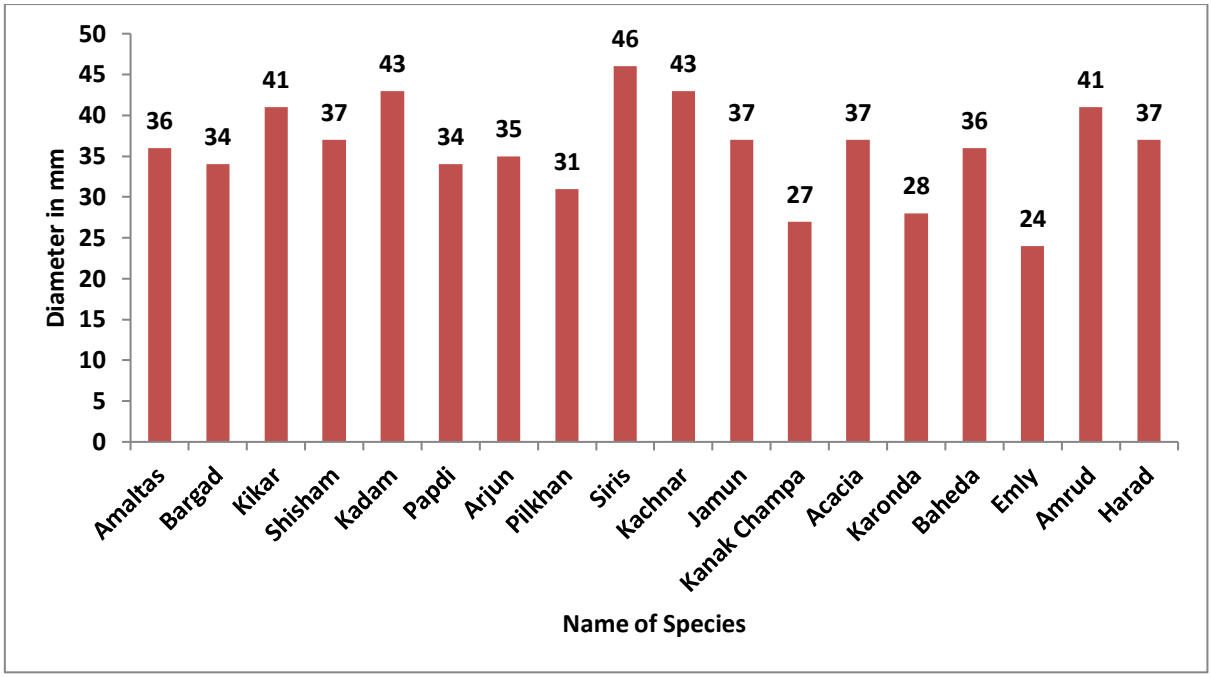


Figure 1.5 Collar Diameters of the Plants

Photos of Asola Bhatti Range

(a)

(b)

(c)

(d)

Fig 15: **(a)** Tughlakabad plantation site
(b) Plantation at Tughlakabad
(c) Plantation at Tughlakabad
(d) Moitoring team at Asola plantation

(e)

(f)

(g)

(h)

Fig 15:(e) Height measurement of plantat Asola plantation
(f) View of Asola plantation
(g) Monitoring team at Bhatti (Radha Swami) plantation
(h) Bhatti (Radha Swami) plantation

1.4.2.4 Mehrauli-II Range

1.4.2.4.1 Field Observations:

i. The plantation site monitored is suitable for the species planted i.e Papdi (*Holoptelea integrifolia*), Shisham (*Dalbergia sissoo*), Kikar (*Acacia nilotica*) and Siris (*Albizzia lebbeck*).
ii. Planting was done on Trench- cum pit method. Plantation was done at the spacing of 3 x 3 meter and at few places the spacing was changed as per site conditions.
iii. Terrain was flat to hilly and slope was varying from 0°-15°.
iv. Plantation is disturbed by wild animals mainly Monkey, Neelgai, Wild boar and Porcupine.
v. Watchers were also deployed for the protection and maintenance of the plantation site.
vi. Plantation journals were not maintained for site and there was no record of inspection by senior officers.
vii. Soil working, weeding, hoeing and mulching are required for moisture conservation. Well-built fencing is required for protection from the wild animals as well as from grazing animals.
viii. Survival of plants is found good (72.00%). There was biotic interference in plantation's site.

Table 1.6 Survival percentages of plants at different sites of Mehrauli-II Range

Sl. No.	Sample Sites	Survival %
1.	Dera Mandi	72.00

1.4.2.4.2 Heights of the Plants: Figure 1.5 shows that in the plantation, maximum average height of 2.1 m was obtained by Shisham followed by Papdi (1.98 m), Kikar (1.41 m), Siris (1.03 m), and Acacia (0.98 m) species in descending order.

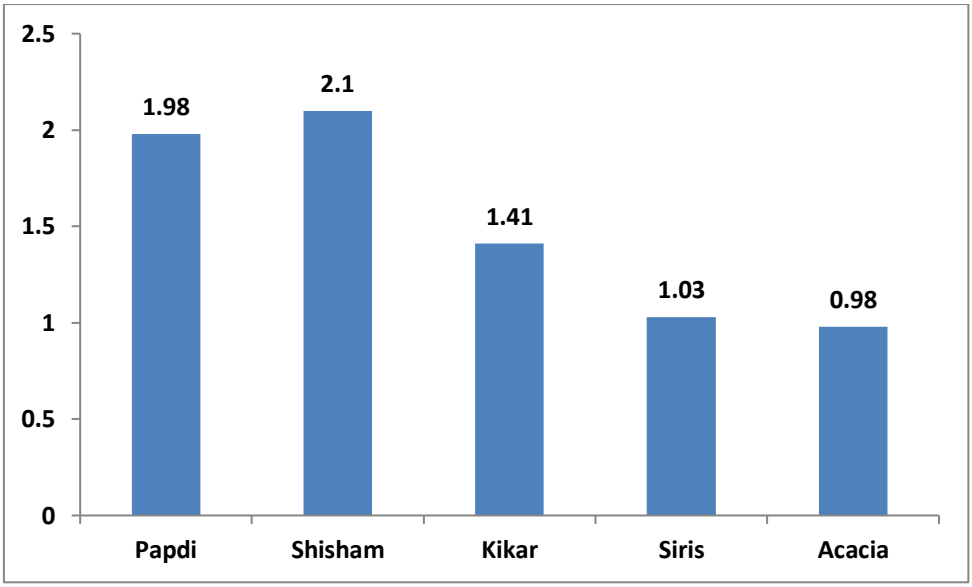


Figure 1.6 Heights (m) of the Plants

1.4.2.4.3 Collar Diameters of the Plants: From the figure 1.7 it was clearly observed that the maximum average collar diameter of 3.9 cm was obtained by Shisham plants followed by Papdi (3.4 cm), Siris (3.2 cm), Kikar (3.1 cm) and Acacia (2.9 cm).

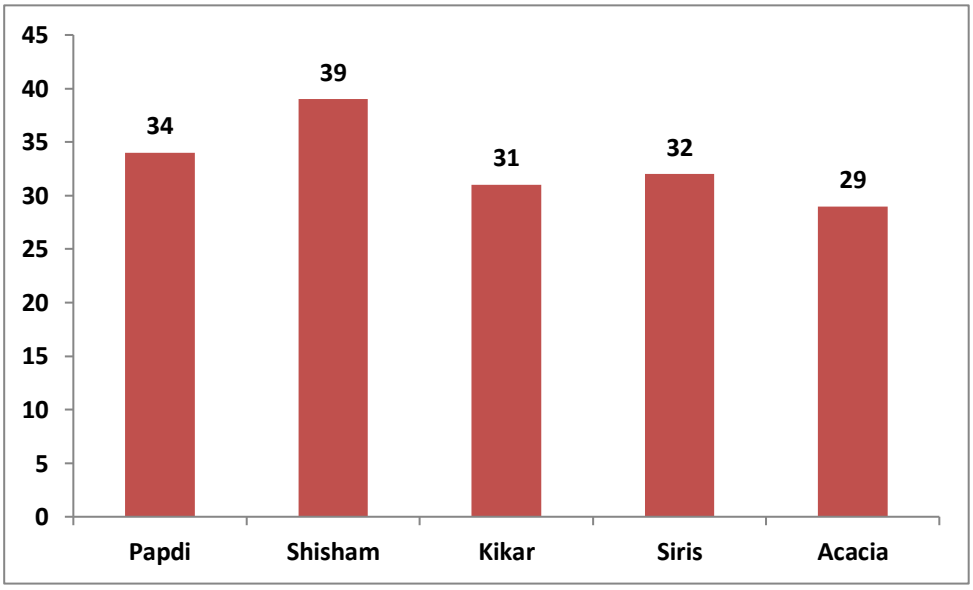


Figure 1.7 Collar Diameters (mm) of the Plants

Photos of Mehrauli-II Range

(a)

(b)

(c)

(d)

Fig 15: **(a)** View of plantation site
(b) Barbed wire fencing
(c) Plants at site
(d) Diameter measurement of plant

1.4.2.5 Eco Task Force

1.4.2.5.1 Field Observations:

i. The plantation sites are suitable for planted species i.eShisham (*Dalbergia sissoo*), Papdi (*Holoptelea integrifolia*), Kikar (*Acacia nilotica*), Reonz (*Acacia leucophloea*), Imli (*Tamarindus indica*), Jamun (*Syzygium cumini)*, Baheda (*Terminalia chebula*), Kachnar (*Bauhinia variegata*), Siris (*Albizzia lebbeck*), Peepal (*Ficus religiosa*), Baken (*Melia azedarach*) and Gulmohar (*Delonix regia*).

ii. Two plantation sites of Eco task force were monitored and both the plantations were undertaken in protected forest area.

iii. Plantation was done on trench- cum pit method and the spacing between row and column was 3 x 3 m which was modified at few places due to site conditions.

iv. Biotic interference and grazing incidents were also observed in the plantation.

v. The wild animals mainly Neelgai, Porcupine and Wild boar cause damaged to plants.

vi. The health of plants was found in good condition and there was no incidence of insect and disease attacks.

vii. In some plantation area water stress was also observed.

viii. Watchmen and Eco- task force staff were deployed for maintenance and protection of plants.

ix. Plantation journals were not maintained at all the sites and there was no record of inspection by senior officers.

x. The average survival of plants is calculated as 84.17%. Survival is better found in Asola (85.85%) then Jounpur (82.50%).

Table 1.7 Survival percentages of plants at different sites of Eco task force

Sl. No.	Sample Sites	Survival %
1.	Asola	85.85
2.	Jounapur	82.50
	Average Survival	**84.17**

1.4.2.5.2 Heights of the Plants: Figure 1.8 shows that maximum average height of 2.45 m was obtained by Shisham followed by Jamun (2.43 m), Baken (2.16 m), Papdi (2.15 m), Kikar (2.03 m), Ticoma (1.94 m), Kachnar (1.67 m), Kadam (1.63 m), Baheda (1.49 m), Acacia (1.43 m), Siris (1.41 m) and Karonda (1.35 m) plants species.

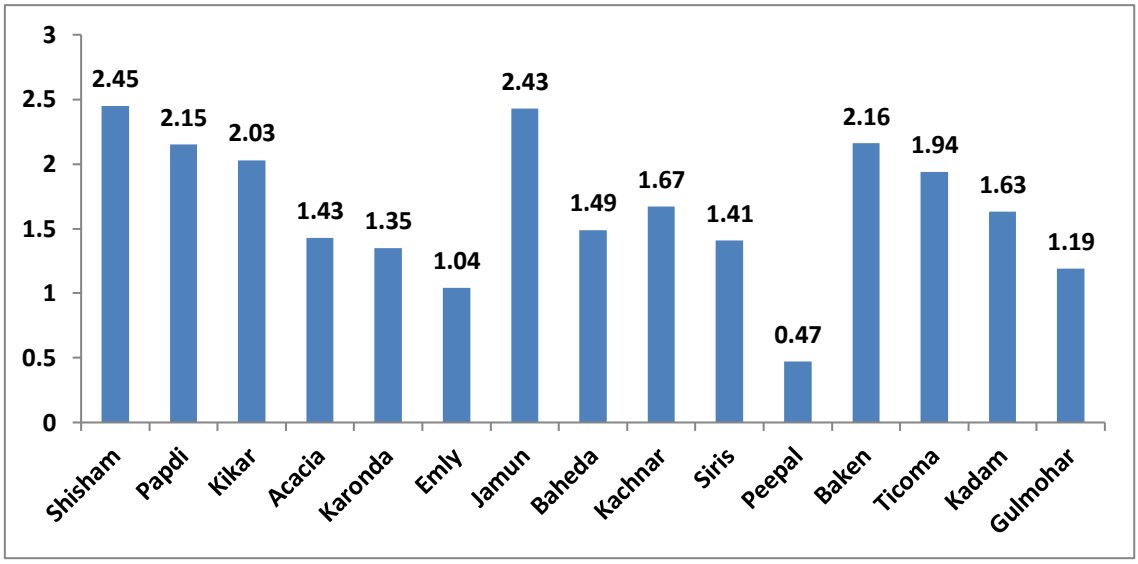


Figure 1.8 Heights (m) of the Plants

1.4.2.5.3 Collar Diameters of the Plants: From figure 1.9, it was clearly observed that maximum average collar diameter of 4.8 cm was obtained by Papdi plants followed by Shisham (4.3 cm), Kikar (4.1 cm), Jamun (3.4 cm), Baken (3.4 cm), Acacia (3.2 cm), Kachnar (3.1 cm), Baheda (2.9 cm), Kadam (2.9 cm), Imli (2.8 cm) and Siris (2.7 cm).

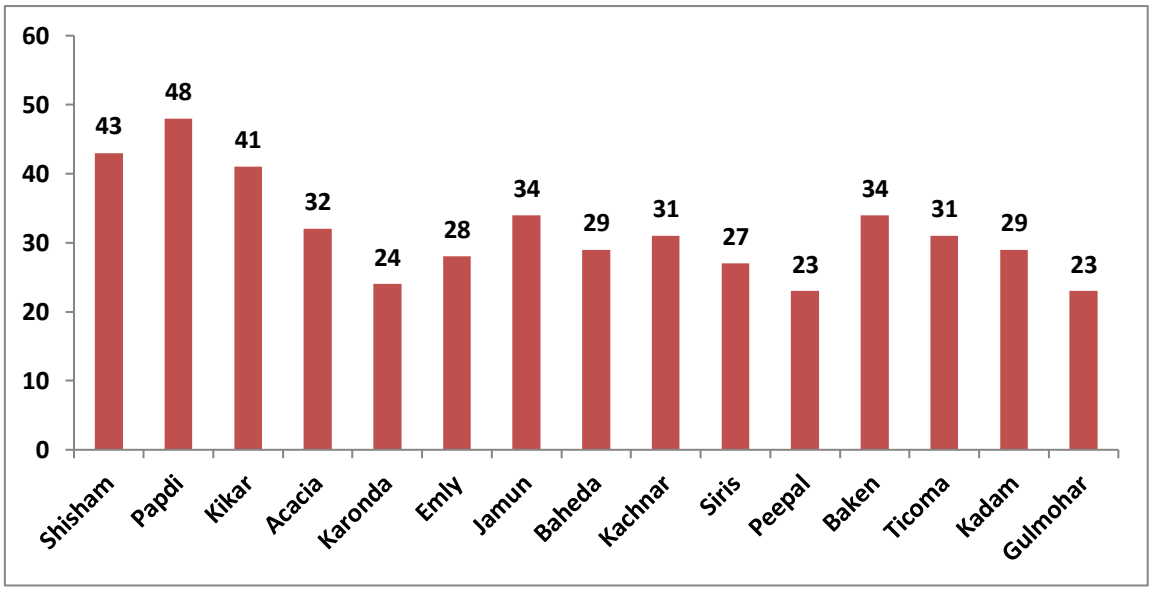


Figure 1.9 Collar Diameters (mm) of the Plants

Photos of Eco Task Force Plantations

(a) **(b)**

(c) **(d)**

Fig 15: **(a)** Jounapur plantation
(b) View of Asola plantation
(c) Laying out sample plot at Jounapur plantation
(d) Diameter measurement of plant

(e)

(f)

(g)

(h)

Fig 15:(e) Field view of Jounapur plantation
(f) Diameter measurement of plant
(g) Monitoring team at Asola plantation
(h) Shisham plant

1.4.3 West Forest Division

Monitoring and evaluation of the plantations raised under NON-CAMPA for the years 2016-17, 2017-18 and 2018-19 was carried out by the team of Forest Research Institute, Dehradun in April 2021. A total of 2 ranges of West Forest Division were covered in this report viz., Najafgarh and Alipur. The target of monitoring of 2016-17 plantations was 8.45 hectare with 4 sites, for the year 2017-18 plantations was 5.20 hectare with 4 sites and for the year 2018-19 plantations; the target was 22.70 hectare with 6 sites. As per sampling procedures, fifty percent of the sites were selected randomly and 10% of area was selected for data collection. GPS coordinates of each sample plot were recorded and presented in the annexure. The data collection sites, field observations, survival and growth of the plants in three forest ranges are given below.

Table 1.8 Sample Sites of West Forest Division under NON-CAMPA

Forest Range	SL. No	Name of the site taken for Monitoring	Area (ha)	Plantation Year
Najafgarh	1.	Kharkhari-1860(19/1,2,9)	1.80	2017-18
	2.	Kharkhari-1050	1.05	2016-17
	3.	Kharkhari-1640 (37/1,2, 36/5, 41/5,7)	1.60	2017-18
	4.	Malikpur-5605	5.60	2016-17
	5.	Ghumanhera-600	0.60	2016-17
	6.	Kharkhari-600(21/6)	0.60	2018-19
	7.	Kharkhari-10800(16/25, 15/2, 18/25)	10.80	2018-19
	8.	Rewla Khanpur-800	0.80	2018-19
	9.	Rewla-300	0.30	2017-18
	10.	Mitraon-9500 Pkt-B	9.50	2018-19
	11.	Mitraon-1220	1.20	2016-17
Alipur	1.	Alipur City Forest-1500	1.50	2017-18
	2.	Mungeshpur-500	0.50	2018-19
	3.	Ghoga-500	0.50	2018-19

1.4.3.1. Monitoring Team:

FRI Team

1. Sh. Nalin Rawat, Junior Research Fellow
2. Sh. Ankit Siraswal, Field Assistant
3. Sh. Ritesh Chauhan, Field Assistant

Najafgarh Range Team

1. Sh. Devender Kumar, Forest Guard

Alipur Range Team

1. Sh. Surender Singh, Deputy Range Officer

1.4.3.2 Date of Survey: 13 April to 17 April, 2021

1.4.3.3 Najafgarh Range

1.4.3.3.1 Field observations:

i. The plantation sites are suitable for planted species i.e. Shisham (*Dalbergia sissoo*), Arjun (*Terminalia arjuna*), Papdi (*Holoptelea integrifolia*), Jamun (*Syzygium cumini*), Neem (*Azadirachta indica*), Bargad (*Ficus benghalensis*), Peepal (*Ficus religiosa*), Pilkhan (*Ficus infectoria*), Kadam (*Anthocephalus chinensis*), Kachnar (*Bauhinia variegata*), Kikar (*Acacia nilotica*), Baheda (*Terminalia bellerica*), Bottle brush (*Callistemon viminalis*), Baken (*Melia azedarach*), Amla (*Emblica officinalis*), Amaltas (*Cassia fistula*) and Kaner (*Nerium indicum*).

ii. There are 11 plantation sites; all the plantations were undertaken on protected forest area in patches.

iii. Plantation was carried out on trench- cum pit method and the spacing between row and column was 3 x 3 m which was modified at few places due to local site conditions.

iv. Biotic interference and grazing incidents were also observed in the plantation sites. Browsing and cutting of plants was observed due to wild animals mainly Porcupine, Wild boar and Neelgai. However, there is no attack of insects and diseases observed on the plants.

v. In some plantation sites, water stress was also observed on the plants.

vi. Watchmen were deployed for maintenance and protection of plantation.

vii. Plantation journals were not available of all the sites and there was no record of inspection by senior officers.

viii. Soil working, weeding, cleaning near by the plants and mulching are required for moisture conservation, effective fencing is required for protection the wild animals as well as grazing animals.

ix. The average survival of plants in Najafgarh range is found to be 75.58%.

Table 1.9 Survival percentages of plants at different sites of Najafgarh Range

SL. No.	Sample Sites	Survival %
1.	Kharkhari-1860(19/1,2,9)	68.20
2.	Kharkhari-1050	72.50
3.	Kharkhari-1640 (37/1,2, 36/5, 41/5,7)	65.30
4.	Malikpur-5605	85.00
5.	Ghumanhera-600	60.28
6.	Kharkhari-600(21/6)	70.10
7.	Kharkhari-10800 (16/25, 15/2, 18/25)	72.80
8.	Rewla Khanpur-800	80.10
9.	Rewla-300	78.20
10.	Mitraon-9500 Pkt-B	88.50
11.	Mitraon-1220	90.50
	Average survival	**75.58**

1.4.3.3.2 Heights of the Plants: Figure 1.10 shows that in the plantations, maximum average height of 2.87 m was recorded by Shisham followed by Arjun (2.16 m), Amaltas (2.16 m), Baken (2.14m), Kadam (1.98 m), *Cassia siamea* (1.9 cm), Jamun (1.89 m), Baheda (1.86 m), Amla (1.83 m), Kaner (1.81 m), Bottle Brush (1.81 m), Neem (1.78 m) and Kachnar (1.73 m) species in descending order.

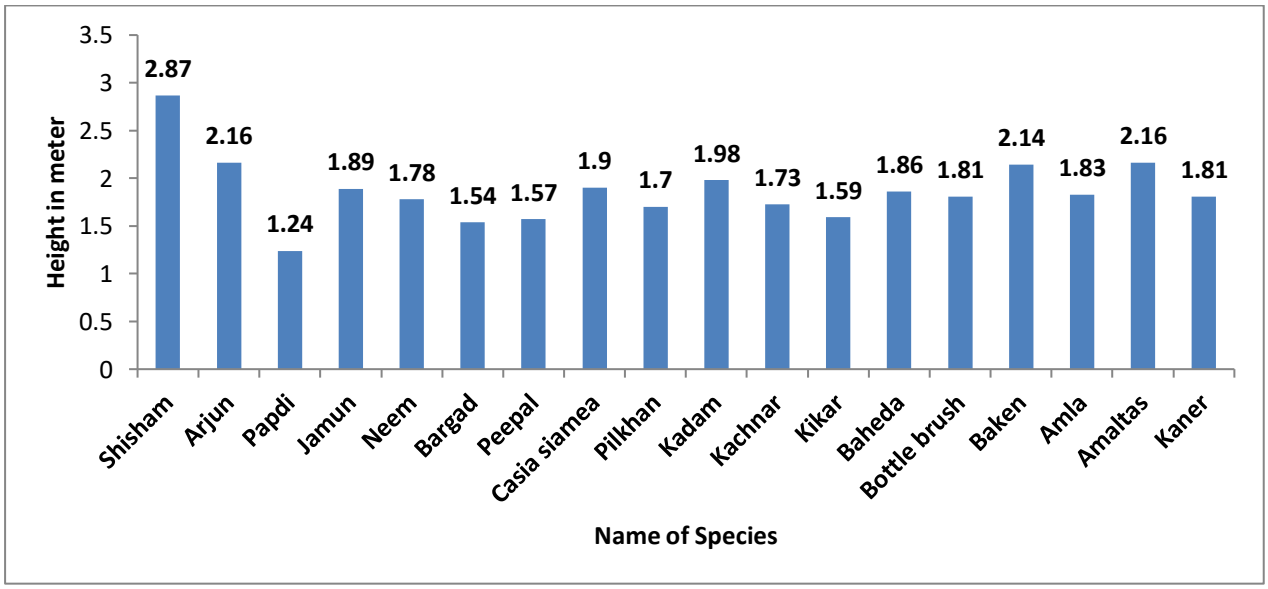


Figure 1.10 Heights of the Plants

1.4.3.3.3 Collar Diameter of the Plants: From the figure 1.11 it was clearly observed that the maximum average collar diameter of 5.9 cm was obtained by Arjun plants followed by Shisham (5.7 cm), Baken (5.1 cm), Amaltas (4.9 cm), Peepal (4.7 cm), Amla (4.6 cm), Bargad (4.4 cm), Jamun (4.3 cm), Bottle brush (4.3 cm), Papdi (4.2 cm), Baheda (4.1) and Kachnar (3.9 cm).

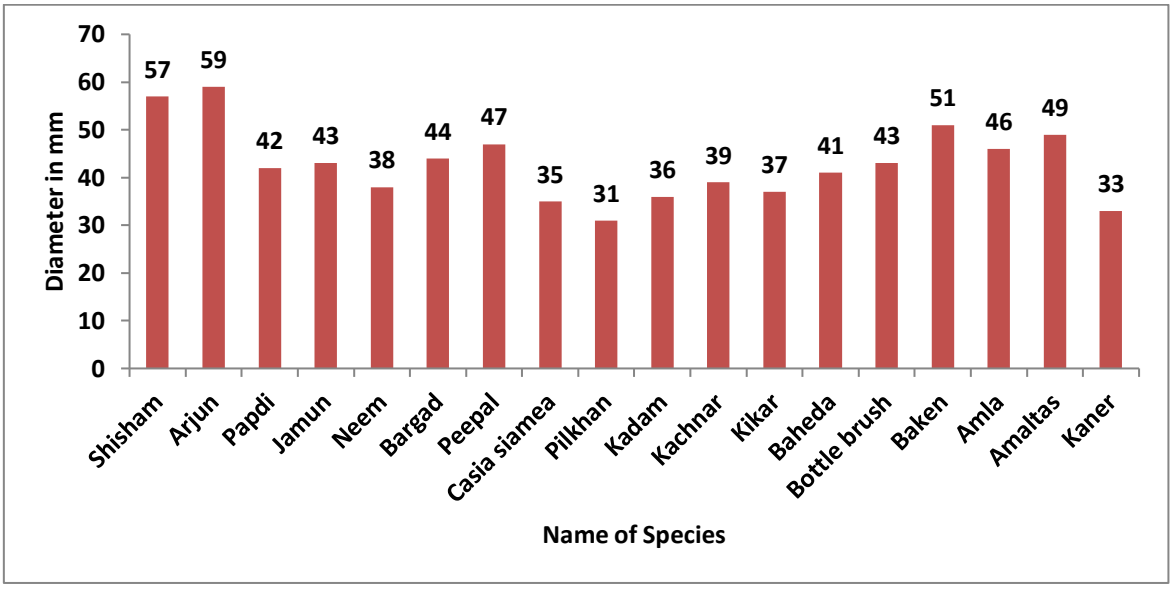


Figure 1.11 Collar Diameters of the Plants

Photos of Najafgarh Range

(a)

(b)

(c)

(d)

Fig 15: **(a)** Kharkhari plantation
(b) Diameter measurement at Kharkhari plantation
(c) Field view of Ghumanhera plantation
(d) Mitraon-Pkt-B plantation

(e)

(f)

(g)

(h)

Fig 15:(e) Mitraon Plantation
(f) Kharkhari plantation
(g) Dry cow dung at Kharkhari plantation site
(h) Height measurement of plant at Malikpur

1.4.3.4 Alipur Range

1.4.3.5 Field Observations:

i. The plantation sites monitored are suitable for planted species i.e Pilkhan (*Ficus infectoria*), Papdi (*Holptelea integrifolia*), Kaner (*Nerium indicum*), Kikar (*Acacia nilotica*) and Shisham (*Dalbergia sissoo*).
ii. There are 3 plantation sites, all the plantations were undertaken in protected forest area in patches and Alipur City Forest plantation was done nearby the range office.
iii. Plantation sites were under low to moderate biotic intervention. Grazing and lopping were seen in all the sites. Plants are affected by stray cattle, Neelgai, Wild boar and Porcupine.
iv. In some plantation areas, water stress was also observed on plants.
v. Watchmen were deployed for maintenance and protection of plantation.
vi. Plantation journals were not maintained at all the sites and there was no record of inspection by senior officers.
vii. The average survival of plants is 77.83%.

Table 1.10 Survival percentages of plants at different sites of Alipur Range

Sl. No.	Sample Sites	Survival %
1.	Alipur City Forest-1500	90.50
2.	Mungeshpur-500	70.20
3.	Ghoga-500	72.80
	Average Survival	**77.83**

1.4.3.6 Heights of the Plants: Figure 1.12 shows that maximum average height of 1.49 m was obtained by Pilkhan followed by Papdi (1.42 m), Kaner (1.34 m), Kikar (1.09 m) and Shisham (1.03 m) plants species.

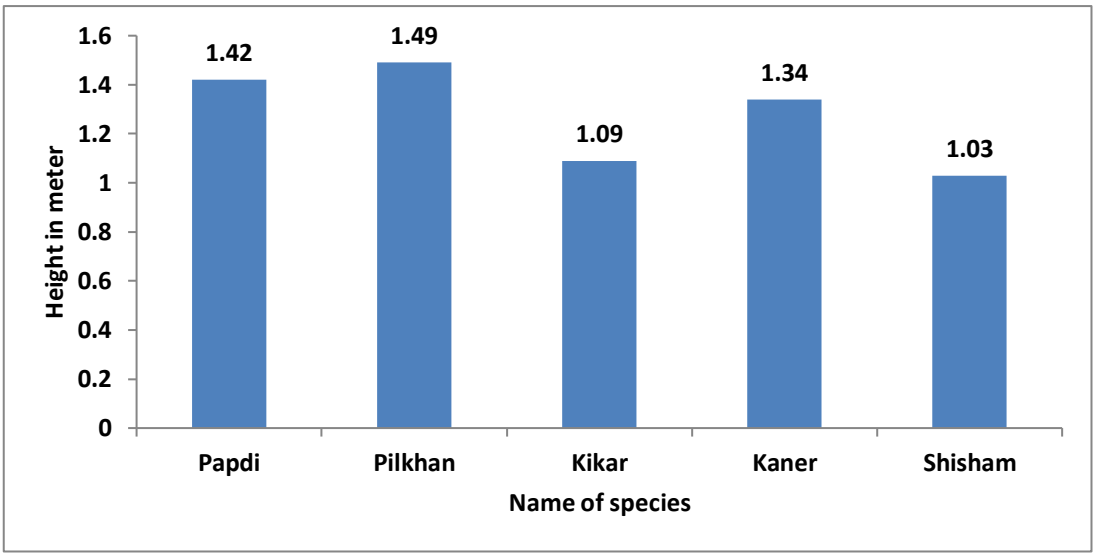


Figure 1.12 Heights of the Plants

1.4.3.7 Collar Diameters of the Plants: From the figure 1.13 it was clearly observed that the maximum average collar diameter of 3.70 cm was obtained by Pilkhan plants followed by Papdi (3.40 cm), Kaner (3.30 cm), Kikar (2.90 cm) and Shisham (2.70 cm).

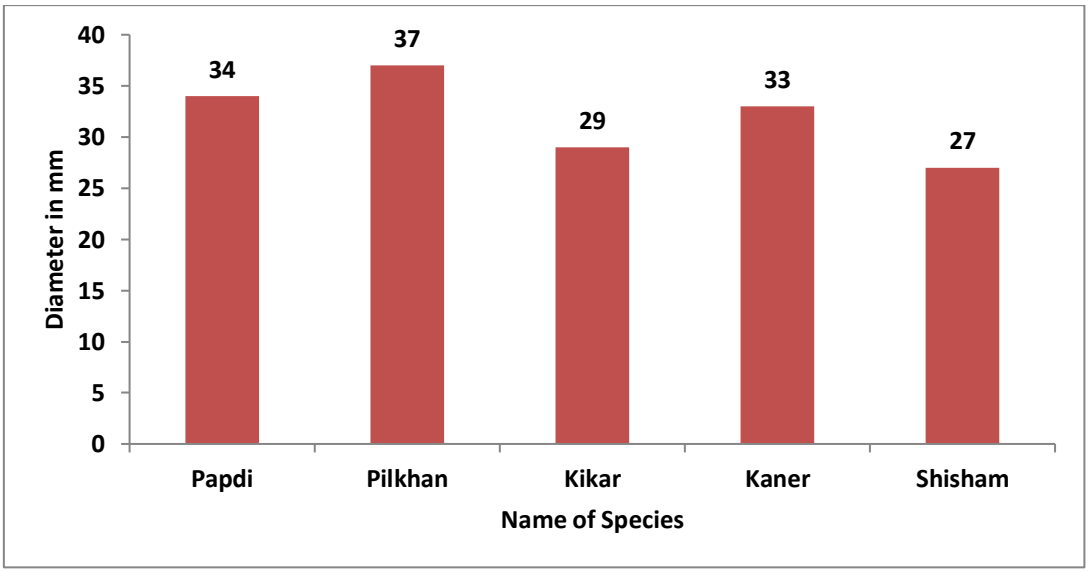


Figure 1.13 Collar Diameters of the Plants

Photos of Alipur Range

(a)

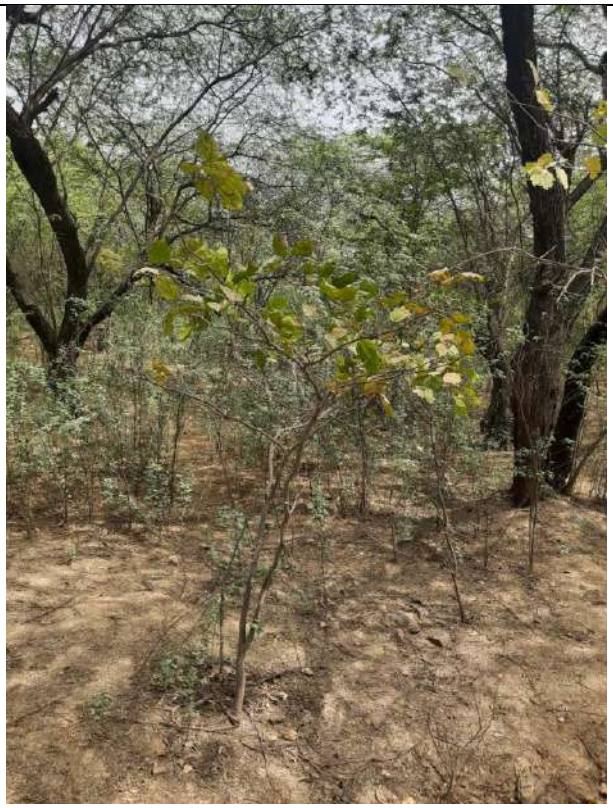
(b)

(c)

(d)

Fig 15: **(a)** Sign board of Alipur City Forest
(b) Plant height measurement at Alipur City Forest
(c) Garbage dumped at Alipur City Forest plantation
(d) Ghoga plantation

(e)



(f)

(g)

(h)

Fig 15: **(e)** Field view of Ghoga plantation
(f) Mungeshpur plantation
(g) View of Mungeshpur plantation
(h) Ghoga plantation

5.1 Lessons learned

The monitoring and evaluation of plantations highlighted following lessons, which may require follow-up action to enhance future outcomes and outputs:-

1. *Plantation record maintenance*: The present analysis found that records of plantations sites were not presented or shown to survey teams. This is a serious problem with respect to monitoring and future implementation of the activities. Only number of plants, names of the sites and GIS maps was shown.

2. *Protection of plantations*: The field data indicate that at many sites the plants were found damaged due to wild animals and stray cattle. The protection measures need to be enhanced in providing protection to the newly planted samplings. There is also risk of damage to the plantations in summer season due to fire. It is, therefore, necessary to provide forest fire control tools to field staff. Forest staff must be trained enough for handling forest fires. The plants raised on the bank of Yamuna river are also prone to damage by flood during rainy season.

3. *Soil and water conservation*: It was also found that soil and water conservation measures were feeble considering the fact that there such measures were not adopted in majority of the sites. The soil and water conservation measures are important for enhancing the productivity of the land, recharge water table and improve the water regime in the plantation sites. In the long run, such measures play significant role in improving the survival rate of plantations by improving the productivity and by increasing soil moisture content. It would be prudent, if the soil and water conservation component is compulsorily included in the plantation programmes and annual work plans.

5. *GIS and remote sensing:* It was observed that the GIS based planning has not been adopted for taking up plantation and soil and water conservation activities in sites selected for plantation. With the simple and easy to use GIS based technology, it becomes very easy to map all plantation patches for further review, monitoring and assessment on regular basis.

5.2. Recommendations

Although the findings of the plantation monitoring presents an encouraging picture, however there are several steps which are suggested be taken up to enhance the outcomes and outputs of the plantation activity in future.

1. ***Site specific APO for the plantation:*** It is imperative to conduct site suitability analysis of the sites well in advance before taking up plantation activities. The advance plantations works should be started after observation of suitability of sites for the plantations. The parameters such as soil characteristics, species suitability, topographic and locality factors should be considered under such assessments prior to plantation planning in a site. It was observed that some sites are not suitable for plantations as people throw garbage in plantation's area and stray cattle menace was also seen. Officials at field level should keep good liaison with people to protect the plantation from grazing or other such biotic pressures.

2. ***Use of Remote Sensing and GIS:*** The degraded lands affected by various land degradation drivers such as salinity, erosion, alkalinity, and water logging in the state should be mapped. Such degraded lands can be reclaimed and rehabilitated by taking up appropriate plantation activities. The GIS and remote sensing techniques are considered to be very helpful in providing more realistic and measurable data.

3. ***Adoption of Suitable Silviculture Practices*:** Evidences from the field surveys and data analysis suggests that the plantation forestry is likely to be sustainable in terms of wood yield in most of the sites provided good practices are maintained. Adoption of improvised silviculture techniques and plantation of native species may further enhance crop productivity. Since, silvicultural practices and species selection are geared to increase the speed of tree growth and shortening rotation periods which is imperative to achieve the goals and targets stated in the State Forest Policy. Fast grown trees like bakain need to be pruned as those trees produced 2-3 leaders from the ground level. Singling will improve growth of trees. Plant to plant spacing of 3 x 3 m should strictly be followed. Thinning in plantation should be carried out to maintain proper spacing of plants. Weeds like Parthenium, lantana, Cannabis and Bathu (Chenopodium) and mesquite trees have assumed alarming proportions at many sites.

These should preferably be removed before flowering, or before seed formation starts in these weeds. The mesquite can gradually be removed by shortening of crown and checking regeneration. The regeneration of native species should be encouraged and protected if natural regeneration is coming up in the forests. Those areas are selected and only ANR activities should be carried out in place of plantation.

4. ***Research needs*:** Rapid assessment of biological richness in the plantation sites need to understand the impact of plantation on biodiversity. The climate change mitigation aspect of the plantations should also need to be assessed as per the area of plantations.

5. ***Plantation of medicinal and aromatic plants*:** It is imperative to cultivate medicinal and aromatic plants considering their conservation importance and its economic benefits for the local communities.

6. ***Plantation of multi purposes tree species (MPTS)*:** The MPTS plantations will be of significant importance in meeting the local needs and for providing alternative livelihood options for the forest dependent communities. The MPTS plantations will also result in enhancing the local's economic conditions.

7. ***Avoid plantation with Exotics*:** It is observed that few exotic species like, *Acacia auriculiformis, A. leucophloea, Callistemon vimilalis* etc. have been planted. The exotic species should be avoided as they are not fit for enhancement of biodiversity. Mixture of native species should be given preference so as to increase biodiversity and ecosystem services.

8. ***Proper plantation inventory maintenance:*** Proper inventory of plantation activities are essential on all plantation sites to track issues, pitfall and for course correction for enhancing outcomes.

9. ***Capacity building and training of field staff involved in plantation activities:*** The field staff needs to be trained with respect to the latest plantation techniques and in forest fire control. Their capacity need to be enhanced on latest advancements in the field of plantation forestry. Training can be provided at Forest Research Institute, Dehradun in afforestation techniques and forest fire management to front line staff to

increase their capacity for conducting field works in more efficient way. The training should be a part of afforestation activities.

10. ***Location specific plantations in consultation with the stakeholder:*** There is a need to have stakeholders' consultation before selecting the plantation species so as to meet the local people's desire and needs.

11. ***Adoption of best practices on land reclamation and restoration*:** The best practices developed elsewhere with similar geographic conditions should be adopted for plantation activities and for enhancing soil moisture regime in the state.

12. ***Enhancement of natural regeneration:*** Aided Natural Regeneration operations should be carried out where regeneration of species is not a problem. Natural regeneration is generally observed in Neem, Beri (*Ziziphus mauritania*), Mulberry, babul, Khajoors (Date palm), Shisham and Burma Drek.

ANNEXURE-I

GIS Maps of Plantation Sites

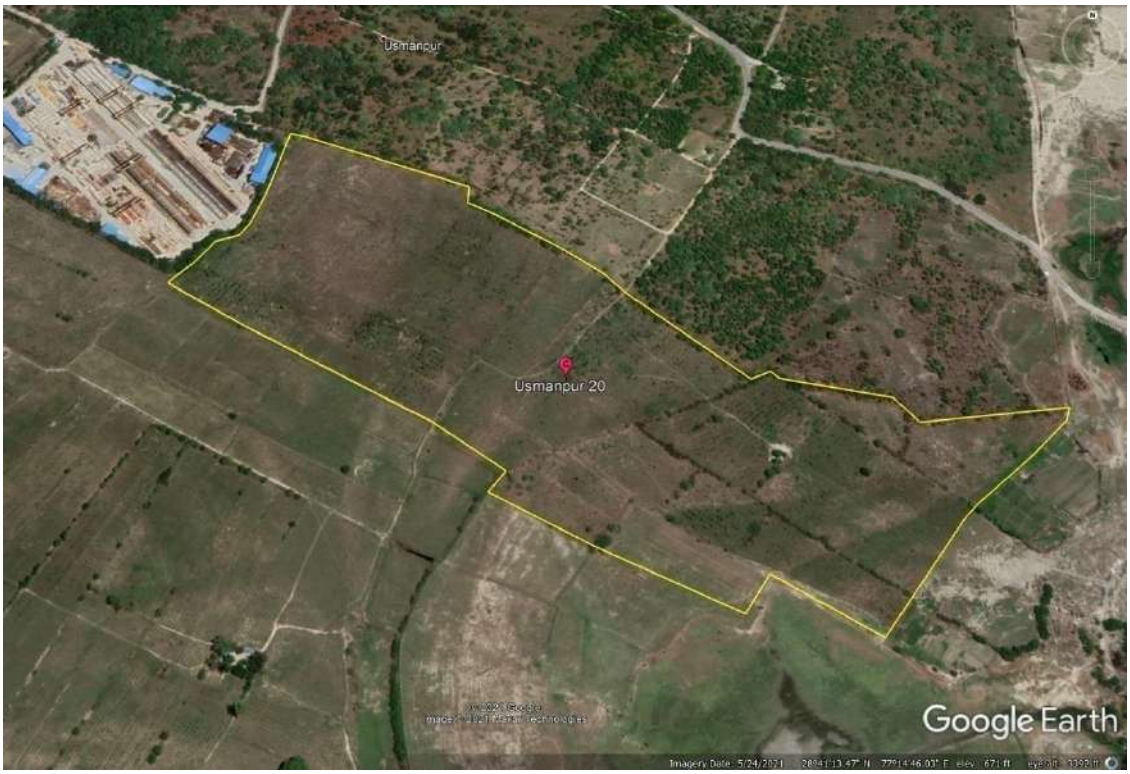
North Forest Division

1. **Shahdra Range**

(i) Yamuna Flood Plains Near IIIrd Pushta, Usmanpur

(ii) Yamuna Flood Plains Near IIIrd Pushta, Usmanpur

(iii) Yamuna Flood Plains, Usmanpur



(iv) Shastri Park Plantation Area Near Bela Farm

(v) Netaji Subhash Chandra Bose Marg

South Forest Division

1. Asola Bhatti Range

(i) Tughlakabad

(ii) Asola

(iii) Bhatti (Radha Swami)

2. Mehrauli-II Range

(i) Dera Mandi

3. Eco Task Force

(i) Asola

(ii) Jounapur

West Forest Division

1. Najafgarh Range

(i) Kharkhari-1860(19/1,2,9)

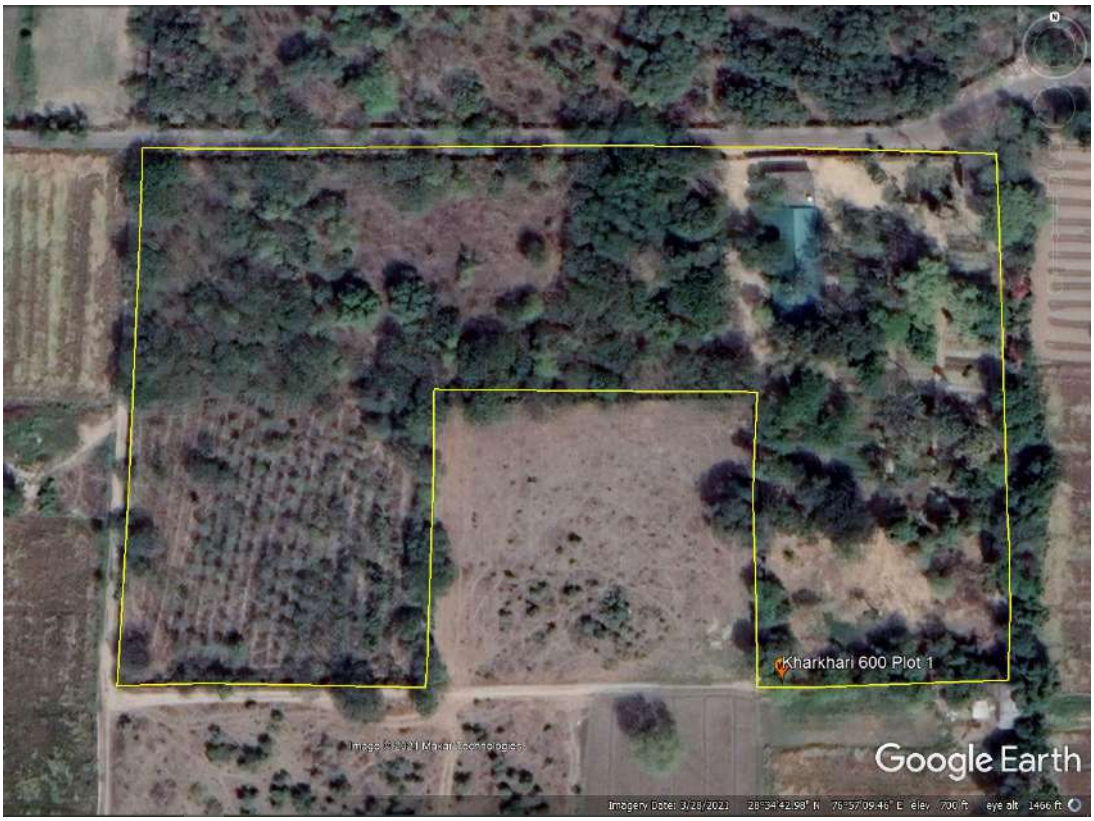
(ii) Kharkhari-1050

(iii) Kharkhari-1640 (37/1,2, 36/5, 41/5,7)

(iv) Malikpur-5605

(v) Ghumanhera-600

(vi) Kharkhari-600(21/6)



(vii) Kharkhari-10800(16/25, 15/2, 18/25)

(viii) Rewla Khanpur-800

(ix) Rewla-300

(x) Mitraon-9500 Pkt-B and Mitraon-1220

2. Alipur Range

(i) Alipur City Forest

(ii) Ghoga-500

(iii) Mungeshpur-500

ANNEXURE-II

Geo-Coordinates of Sample Plots

1. West Forest Division

1. Najafgarh Range

(i) Kharkhari-1860(19/1,2,9) (1.80 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°34'43.05"N	76°56'33.26"E
2	28°34'41.89"N	76°56'33.27"E

(ii) Kharkhari-1050 (1.05 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°34'10.39"N	76°56'40.23"E

(iii) Kharkhari-1640 (37/1,2, 36/5, 41/5,7) (1.60 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°34'05.72"N	76°56'33.07"E
2	28°34'05.03"N	76°56'32.60"E

(iv) Malikpur-5605 (5.60 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°33'28.74"N	76°53'31.47"E
2	28°33'38.06"N	76°53'42.48"E
3	28°33'47.09"N	76°53'42.37"E
4	28°33'48.17"N	76°53'33.18"E
5	28°33'56.42"N	76°53'35.76"E
6	28°33'57.32"N	76°53'36.28"E

(v) Ghumanhera-600 (0.60 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°31'10.11"N	76°55'51.61"E

(vi) Kharkhari- 600 (21/6) (0.60 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°34'40.60"N	76°57'08.62"E

(vii) Kharkhari-10800 (16/25, 15/2, 18/25) (10.80 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°34'03.57"N	76°57'35.64"E
2	28°34'05.62"N	76°56'27.87"E
3	28°34'07.56"N	76°56'28.01"E
4	28°34'08.22"N	76°56'28.12"E
5	28°34'09.70"N	76°56'28.32"E
6	28°34'09.80"N	76°56'25.98"E
7	28°34'08.36"N	76°56'25.98"E
8	28°34'44.90"N	76°56'31.52"E
9	28°34'46.82"N	76°56'31.72"E
10	28°34'46.84"N	76°56'29.32"E
11	28°34'44.97"N	76°56'29.05"E

(viii) Rewla Khanpur-800 (0.80 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°33'44.49"N	76°58'31.56"E

(ix) Rewla-300 (0.30 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°34'20.11"N	76°58'51.08"E

(x) Mitraon-9500 Pkt-B (9.50 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°36'47.14"N	76°56'26.19"E
2	28°36'49.54"N	76°56'28.32"E
3	28°36'54.76"N	76°56'28.68"E
4	28°37'0.03"N	76°56'30.05"E
5	28°37'2.17"N	76°56'25.89"E
6	28°36'59.20"N	76°56'34.04"E
7	28°36'56.66"N	76°56'32.59"E
8	28°36'54.32"N	76°56'34.98"E
9	28°36'51.68"N	76°56'32.67"E

10	28°36'46.90"N	76°56'31.56"E

(xi) Mitraon-1220 (1.20 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°36'46.97"N	76°56'34.25"E
2	28°36'54.86"N	76°56'38.12"E

2. Alipur Range

(i) Alipur City Forest-1500 (1.50 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°47'41.07"N	77°07'49.39"E
2	28°47'38.97"N	77°07'55.74"E

(ii) Mungeshpur-500 (0.50 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°48'42.05"N	76°58'12.27"E

(iii) Ghoga-500 (0.50 ha)

Plot No.	LATITUDE	LONGITUDE
1	28°49'32.80"N	77°03'31.89"E

2. North Forest Division

1. Shahdra Range

(i) Yamuna Flood Plains Near IIIrd Pushta Usmanpur (14.65ha)

Plot No.	LATITUDE	LONGITUDE
1.	28°41'33.68"N	77°14'14.89"E
2.	28°41'32.11"N	77°14'14.07"E
3.	28°41'30.38"N	77°14'12.98"E
4.	28°41'29.01"N	77°14'11.69"E
5.	28°41'29.91"N	77°14'9.82"E
6.	28°41'31.37"N	77°14'11.56"E
7.	28°41'33.13"N	77°14'10.16"E
8.	28°41'35.94"N	77°14'5.85"E
9.	28°41'35.06"N	77°14'1.80"E
10.	28°41'35.59"N	77°13'58.78"E
11.	28°41'39.74"N	77°13'55.52"E
12.	28°41'37.41"N	77°14'0.24"E
13.	28°41'34.92"N	77°14'8.16"E
14.	28°41'37.91"N	77°14'7.57"E
15.	28°41'34.56"N	77°14'11.15"E

(ii) Yamuna Flood Plains Near IIIrd Pushta Usmanpur (14.45 ha)

Plot No.	LATITUDE	LONGITUDE
1.	28°41'31.25"N	77°14'2.16"E
2.	28°41'31.72"N	77°13'59.39"E
3.	28°41'31.37"N	77°13'56.70"E
4.	28°41'29.97"N	77°13'56.95"E
5.	28°41'29.90"N	77°13'59.98"E
6.	28°41'28.63"N	77°14'2.68"E
7.	28°41'26.63"N	77°14'0.25"E
8.	28°41'25.31"N	77°13'56.28"E
9.	28°41'23.33"N	77°13'56.33"E
10.	28°41'23.27"N	77°14'3.00"E
11.	28°41'21.52"N	77°14'1.06"E
12.	28°41'21.27"N	77°13'57.15"E
13.	28°41'18.24"N	77°13'58.75"E
14.	28°41'17.68"N	77°14'1.01"E
15.	28°41'16.78"N	77°14'2.64"E

(iii)Yamuna Flood Plains Usmanpur (20ha)

Plot No.	LATITUDE	LONGITUDE
1.	28°41'23.00"N	77°14'34.40"E
2.	28°41'21.62"N	77°14'37.96"E
3.	28°41'19.72"N	77°14'41.90"E
4.	28°41'17.31"N	77°14'44.86"E
5.	28°41'21.20"N	77°14'32.96"E
6.	28°41'19.01"N	77°14'36.39"E
7.	28°41'16.21"N	77°14'40.42"E
8.	28°41'19.73"N	77°14'31.30"E
9.	28°41'17.89"N	77°14'34.84"E
10.	28°41'16.53"N	77°14'38.22"E
11.	28°41'12.27"N	77°14'45.46"E
12.	28°41'11.32"N	77°14'48.01"E
13.	28°41'10.85"N	77°14'51.66"E
14.	28°41'13.01"N	77°14'43.11"E
15.	28°41'14.69"N	77°14'43.27"E
16.	28°41'15.64"N	77°14'48.24"E
17.	28°41'13.17"N	77°14'47.72"E
18.	28°41'14.43"N	77°14'51.73"E
19.	28°41'13.90"N	77°14'54.91"E
20.	28°41'12.80"N	77°14'52.16"E

(iv)Shastri Park Plantation Area Near Bela Farm (9.15 ha)

Plot No.	LATITUDE	LONGITUDE
1.	28°40'25.73"N	77°14'24.92"E
2.	28°40'26.68"N	77°14'27.58"E
3.	28°40'27.47"N	77°14'30.37"E
4.	28°40'28.82"N	77°14'25.54"E
5.	28°40'30.08"N	77°14'28.22"E
6.	28°40'31.89"N	77°14'24.33"E
7.	28°40'27.93"N	77°14'22.40"E
8.	28°40'30.98"N	77°14'20.52"E
9.	28°40'32.47"N	77°14'26.19"E
10.	28°40'28.79"N	77°14'33.02"E

(v) Netaji Subhash Chandra Bose Marg (2 ha)

Plot No.	LATITUDE	LONGITUDE
1.	28°37'47.00"N	77°16'9.04"E
2.	28°37'44.20"N	77°16'2.22"E

3. South Forest Division

1. Asola Bhatti Range

(i) Tughlakabad (32.5 ha)

Plot No.	LATITUDE	LONGITUDE
1.	28°29'2.30"N	77°15'1.81"E
2.	28°29'3.06"N	77°15'0.27"E
3.	28°29'1.03"N	77°15'0.97"E
4.	28°29'2.03"N	77°14'59.03"E
5.	28°29'2.99"N	77°15'4.45"E
6.	28°29'1.71"N	77°15'5.37"E
7.	28°29'3.07"N	77°14'54.91"E
8.	28°29'1.08"N	77°14'56.68"E
9.	28°29'3.20"N	77°14'52.36"E
10.	28°28'58.43"N	77°14'58.53"E
11.	28°28'58.82"N	77°15'0.98"E
12.	28°28'59.07"N	77°15'3.77"E
13.	28°28'59.83"N	77°15'7.11"E
14.	28°28'57.96"N	77°15'7.96"E
15.	28°28'57.21"N	77°15'9.82"E
16.	28°28'55.83"N	77°15'8.83"E
17.	28°28'56.51"N	77°15'6.23"E
18.	28°28'54.53"N	77°15'5.01"E
19.	28°28'55.85"N	77°15'2.71"E
20.	28°28'54.48"N	77°15'1.75"E

(ii) Asola (4ha)

Plot No.	LATITUDE	LONGITUDE
1.	28°27'1.75"N	77°12'41.95"E
2.	28°27'0.38"N	77°12'44.58"E
3.	28°26'58.46"N	77°12'48.75"E
4.	28°27'1.31"N	77°12'46.23"E

(iii) Bhatti (Radha Swami) 7.2 ha

Plot No.	LATITUDE	LONGITUDE
1.	28°26'1.69"N	77°12'42.72"E
2.	28°26'10.87"N	77°12'47.38"E

3.	28°26'8.69"N	77°12'52.99"E
4.	28°26'5.20"N	77°12'42.29"E
5.	28°26'9.24"N	77°12'44.37"E
6.	28°26'5.84"N	77°12'46.41"E
7.	28°26'4.82"N	77°12'49.73"E
8.	28°26'8.14"N	77°12'49.35"E

2. Mehrauli-II Range

(i) Dera Mandi (3ha)

Plot No.	LATITUDE	LONGITUDE
1.	28°25'36.06"N	77°11'2.96"E
2.	28°25'35.47"N	77°10'59.55"E
3.	28°25'37.22"N	77°11'3.27"E

3. Eco Task Force

(i) Asola (26.60 ha)

Plot No.	LATITUDE	LONGITUDE
1.	28°27'54.80"N	77°12'52.59"E
2.	28°27'55.18"N	77°12'50.44"E
3.	28°27'55.29"N	77°12'48.13"E
4.	28°27'57.20"N	77°12'49.51"E
5.	28°27'57.17"N	77°12'51.86"E
6.	28°27'53.49"N	77°12'49.47"E
7.	28°27'53.57"N	77°12'47.40"E
8.	28°27'53.69"N	77°12'45.67"E
9.	28°27'52.48"N	77°12'46.77"E
10.	28°27'53.25"N	77°12'42.96"E
11.	28°27'51.62"N	77°12'42.54"E
12.	28°27'50.09"N	77°12'41.31"E
13.	28°27'49.17"N	77°12'43.14"E
14.	28°27'48.73"N	77°12'44.87"E
15.	28°27'52.42"N	77°12'49.81"E
16.	28°27'52.90"N	77°12'52.45"E
17.	28°27'52.06"N	77°12'54.23"E
18.	28°27'53.76"N	77°12'54.14"E
19.	28°27'54.80"N	77°12'55.96"E
20.	28°27'52.99"N	77°12'56.30"E

(ii) Jounapur (14.20 ha)

Plot No.	LATITUDE	LONGITUDE
1.	28°27'19.78"N	77° 8'14.75"E
2.	28°27'14.49"N	77° 8'15.80"E
3.	28°27'12.16"N	77° 8'22.66"E
4.	28°27'17.75"N	77° 8'20.60"E
5.	28°27'19.96"N	77° 8'19.19"E
6.	28°27'17.40"N	77° 8'16.35"E
7.	28°27'17.95"N	77° 8'13.15"E
8.	28°27'14.08"N	77° 8'13.23"E
9.	28°27'13.21"N	77° 8'9.78"E
10.	28°27'11.18"N	77° 8'12.47"E
11.	28°27'12.12"N	77° 8'15.97"E
12.	28°27'11.97"N	77° 8'19.84"E
13.	28°27'13.25"N	77° 8'24.69"E
14.	28°27'15.45"N	77° 8'28.88"E