A Report
On

TREE TRANSLOCATION IN INDIA

Submitted to
Ministry of Environment, Forest & Climate Change
(Govt. of India)
Indira Paryavaran Bhawan, Jor Bagh
New Delhi-110003

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EXECUTIVE SUMMARY

Trees bring a plethora of benefits, economical, ecological and social. Therefore, promotion of extensive plantation activities globally and nationally is the need of the hour to bring back ecological equilibrium and atmospheric amelioration. Urbanization and road widening projects in many parts of the country lead to removal of large number of trees every year. To reverse this trend the concept of transplanting of such trees from their original sites to the other available sites is gaining momentum, however no systematic studies on the subject is available to recommend. Tree transplantation process involves great engineering and arborist skills to make it work effectively apart from substantial amount of resources, money and time.

The discussions on the subject of tree translocation/ transplantation were held in Ministry of Environment Forest and Climate Change on 12.02.2020 and the Project Monitoring Group held discussions on this subject on 4.03.2020 and 19.04.2020, while reviewing the issues of PMG projects. During these discussions, the Hon'ble Commerce & Industry Minister directed that a study should be conducted by the MoEF&CC in consultation with the States concerned to document the best practices and technology used for tree transplantation instead of tree cutting while executing the infrastructure projects. Accordingly, ICFRE has been assigned the task of conducting a survey on the best available technological solutions for different types of trees and their suitability for tree transplantation; and to prepare a database of agencies both in public and private sectors and high-tech transplanting machinery available for tree transplantation.

To take up this study on feasibility of transplantation of trees while developing infrastructure projects, Forest Research Institute, Dehradun requested the State forest departments to share the practices and technologies used by them for tree translocation. The response of 17 States and Union Territories were received, which has been analysed and consolidated for presenting in this report. The States of Himachal Pradesh, Kerala, Madhya Pradesh, Meghalaya and Tripura have reported that they have not carried out translocation of trees in their States and their State forest departments are not equipped to carry out these specialized activities. The statistics from the states revealed that no standardized technique of tree translocation is followed by any State rather the agency/ department follows the procedure based on own past experience or based on available literature in this regard.

The record of survival data from States is available for a maximum of 5 years and only Uttar Pradesh has shown survival of trees upto 5 years of transplanting. The data showed that *Ficus spp.*, *Dalbergia sissoo* (shisham), *Cassia fistula* (amaltas), *Pongamia pinnata* (kanji) *Peltophorum pterocarpum (*pila gulmohar*), Terminalia arjuna (*arjun*), Delonix regia (*gulmohar*), Albizzia lebbeck* (siras*), Phoenix sylvestris (khajur), Samanea saman (Rain tree), Syzygium cumini (*jamun*), Aegle marmelos (Bel),* and *Tectona grandis* (teak) have more than 80% survival after two years of translocation. Survival of trees having more than 70 cm diameter is found to be less in comparison to the trees of lower diameter class. Based on the data it is evident that *Ficus spp.*, *Peltophorum pterocarpum (*Pila gulmohar*), Delonix regia (Gulmohar)* and *Cassia fistula (Amaltas)* are having better survival in maximum States in the country while some species like *Dalbergia sissoo* (Shisham) and *Syzygium cumini (Jamun)* are successful in only specific regions.

Though hundreds of species are used in the urban environment, hardy native species like *Ficus benghalensis, Ficus religiosa, Pongamia pinnata, Zizyphus mauritiana, Terminalia arjuna, Syzygium cumini, Mangifera indica, Artocarpus hirsutus* etc., having faster recovery are preferred over exotic species. The native species are found to survive better than exotic ones. The tree species which produce coppice shoots have better chances of survival after translocation if proper care is taken. The trees with poor health and structural defects are not favourable for translocation.

Based on the information received about agencies active in the field of tree translocation it is seen that there are 3 government and 12 private agencies involved in tree translocation in the Country. Out of 12 private agencies, 6 agencies have reported their annual turnover more than 1 crore. Heavy machineries and cost is involved in tree translocation. It has been reported that NHAI has spent around Rs. 30,000 per tree for transplanting in Haryana. However, as reported by the states and other agencies that per tree cost of tree translocation varied from State to State (Rs. 4,000 to Rs.45,774). There are various machines and tools being used for tree translocation like JCB, Crane, Truck with loader, Pit Digger, DAMCON Tree Transplanter KLR-2M. Gujarat State Forest Department has used a Composite Tree Transplanter machine mounted on a heavy truck chassis which performed pit digging, uprooting tree keeping its root stocks and earth ball intact, transplanting a new site and filling the pit with dug up soil. The cost is found increased with manual translocation in place of using machines. There has not been found any correlation between diameters of trees with the translocation cost. To cite a few, examples a tree translocator in Delhi (M/S Rohit Nursery) had submitted the unit cost for tree translocation of trees of various girth classes ranging from a minimum of Rs. 4,750 for range of 0-30 cm to a maximum of Rs. 22,500 for girth range of 201-500 cm. Gujarat, on the other hand, has stated that the estimated cost of translocation is Rs. 4000/ per tree, without accounting for the machinery purchased by the department.

The data obtained is not consistent to draw any conclusion for recommending translocation as a matter of rule in infrastructure projects. However, based on the experience of States, their best practices which yielded maximum survival have been compiled to guide the translocation of trees. There exists an option of ways/methods of carrying out tree transplantation. These have to be studied and cost-effective technologies for different scenarios like small scale, large scale tree translocation should be worked out. It is also suggested that research is required for developing SOP for preparation of field manual and standard processes for tree translocation related to different agro-climate zones of the country.

A REPORT ON TREE TRANSLOCATION

(FEASIBILITY OF TRANSPLANTATION OF TREES WHILE DEVELOPING INFRASTRUCTURE PROJECTS)

I BACKGROUND: Urbanization and development are inevitable parts of modern age. Road widening and building of flyovers is needed in every growing city, but this comes at the cost of losing green cover. Planting trees is necessary to maintain canopy cover and to replace trees that have been removed or lost due to natural mortality or other challenges like constructions, impacts from adverse weather conditions such as storms, wind, ice, snow, flooding and drought, invasive pests etc. Tree transplantation is a process of unearthing the trees and replanting them from their parent locations to new locations with objective of re-growing the trees at new locations. The key concern remains in protecting the root ball while pruning the wider roots. The process involves great engineering and arborist skills to make it work effectively. It also requires substantial amount of resources and time.

This report is an outcome of the collection and analysis of the experiences of different State Departments who have explored the option of tree transplantation instead of extensive removal of the trees for infrastructure projects in their jurisdiction.

The guidelines for the species suitability, preferable diameter class, planting techniques and post planting care for tree translocation have been prepared based on the data provided by the UTs and States of Andhra Pradesh, Bihar, Chandigarh, Gujarat, Haryana, Jharkhand, Karnataka, Maharashtra, New Delhi, Tamil Nadu, Punjab, Uttarakhand and Uttar Pradesh and literature survey. The States of Himachal Pradesh, Madhya Pradesh, Meghalaya, Kerala and Tripura have reported that they have not carried out translocation of trees in their State. These forest departments are not equipped to carry out these activities.

Attempt was made to collect the data on survival percentage of trees translocated in different infrastructure projects in the above States/UTs. The survival of trees (in some cases species wise) is compiled state-wise and placed at Annexure-1**.** The maximum reported duration of survival of any translocated tree, among cases studied is 05 years in case of translocation carried out by Rohit Nursery during the year 2015-16 in Agra, Uttar Pradesh. The survival of translocated trees more than 50% upto 5 years of transplantation and the species of more than 80% survival after two years are presented in Annexure-2. Suggestive list of favourable species for translocation including their zone-wise performance is listed in Annexure-3.

National data base of tree translocation was invited from various agencies involved in tree translocation by FRI through website and news papers. The information was sought on experience, registration, turnover and other documents of the agency. The database of agencies involved in tree translocation has been compiled and categorized into annual turnover and experience of work executed by them in tree translocation in past (Annexure-4).

The high-tech transplanting machinery available for tree transplantation has been compiled from the secondary sources and also as shared by some of the agencies who have carried out tree translocation projects for government departments (Annexure-5).

II. BEST AVAILABLE TECHNOLOGICAL SOLUTIONS FOR DIFFERENT TYPES OF TREES AND THEIR SUITABILITY FOR TREE TRANSPLANTATION - BASED ON EXPERIENCES FROM DIFFERENT STATES AND SECONDARY SOURCES:

A. Suitability for tree transplantation - Experiences from different States and secondary sources:

The National Seminar on Green Cover Retention: Critical Need, Policy and Practices jointly hosted by Institute of Wood Science and Technology (IWST) and Volvo Trucks India (VTI) with support of the Indian Council of Forestry Research and Education (ICFRE), Ministry of Environment, Forest & Climate Change (MoEF&CC) on 31st October, 2017 at Bangalore *inter alia* recommended that the assessment of the potential technologies for tree transplantation needs to be done. There exists plethora of ways/methods of carrying out tree transplantation. These have to be studied and cost-effective technologies for different scenarios like small scale, large scale tree translocation should be worked out. It also recommended for developing species-wise Standard Operating Procedures (SOP) for tree transplantation. Continuous research for developing SOP should be taken up to develop field manual and standard processes related to different agro-climate zones.

The state-wise attempts of translocation of trees in few projects are summarized below:

2.1 Andhra Pradesh

In the year **2017**, NHAI took up transplantation for the infrastructure project "Construction of flyover at NH-16 & 65 junction at Benz circle, NH-16, Vijayawada, Andhra Pradesh" through A.P. Greening and Beautification Corporation, Vijayawada. The state has reported success in transplantation in few projects upto a maximum period of 5 years. The cost of Rs. 13,000 per tree was incurred in translocation with the total amount of Rs. 35,36,000 was spent on translocation of 272 trees. Truck mounted automated equipment was used for translocation (pit digging, uprooting tree keeping its root stocks and earth ball intact, transplanting a new site and filling the pit with dug up soil).

Current Status – All survived trees are growing with abundant branches and foliage.
(*Annexure-1 at sl. no.1*).

2.2 Chandigarh

Around 20 years old tree of *Bombax ceiba* (semal) of 205 cm diameter was planted at City forest near Sukhna lake in **2020**. Only single tree was transplanted with the cost of Rs. 20,000. The big tree was transplanted with the help of Hydraulic Crane, JCB and transported by a truck.

The tree is surviving at present (*Annexure-1 at sl. no.2*).

2.3 Delhi:

- Gandhiok (**2019**) reports that Delhi government has announced a tree transplantation policy in which 80% of trees being felled for an approved project would have to be mandatorily transplanted. But in earlier carried out transplantation of peepal trees by DMRC, shifting them to Asola Bhatti Wildlife Sanctuary, was observed that survival rate was very low.
- A report of Aggarwal (**2018**) describes, transplanting trees is an expensive affair and not many in India can claim to be an expert at the meticulous process. The survival depends on the consistent care of uprooted trees and a lot of complementary factors that are difficult to control. The success rate in certain cities in India has been as low as 2 percent. With this higher costs and lower success rate, tree transplantation as a feasible solution is questionable.
- Nandi (**2018**) reports that transplanting is not the best alternative, usually after all the efforts, most transplanted trees do not survive the ordeal. According to data provided in the permission letters issued by Forest Department, Government of Delhi to National Buildings Construction Corporation (NBCC), only 175 out of the 2490 trees that were transplanted, survived in Netaji Nagar and only 11 of 1465 in Nauroji Nagar survived after transplantation. This report further states that according to Professor C. R. Babu, Professor Emeritus; Centre for Environmental Management of Degraded Ecosystems, "Majority of tree cannot tolerate prevalent transplantation shock, particularly big and old trees, hence a success rate is extremely low. However some *Ficus* species like peepal and banyan are likely to survive, but not many other"

In the year **2009,** 31 trees of *Altstonia scholaris* (alstonia) & 14 trees of miscellaneous species were relocated at **IIT campus Hauz khas**. At the time of uprooting, trees diameter range was 20-40 cm. The cost of translocation per tree was charged as per diameters of trees. The average translocation cost of each tree is estimated as Rs. 6,966. The total amount of Rs. 3,13,470 was spent on translocation of 45 trees. JCB, Tractor and Crane were used for translocation.

In **2008**, 150 trees of species such as *Grevellia robusta* (silver oak), *Putranjiva roxburghii* (putranjiva), Fish tail palm, *Albizzia leebeck* (siris), *Cellistemon viminalis* (bottle brush), *Ficus spp.* and *Terminalia arjuna* (arjun) were planted **at DDA park, Dhaula Kuwan**. At the time of planting, species diameter range was 0-93 cm. The average translocation cost of each tree is estimated as Rs. 9,025. The total amount of Rs. 11,28,125 was spent on translocation of 125 trees. JCB, Tractor and Crane were used for translocation.

After four years of transplantation, it was found that 85% of the species were surviving in above sites. Thereafter the data is not available.

The survival and other details of trees are given in *Annexure-1 at sl. no. 3.*

2.4 Gujarat

Gujarat is one of the early adopters of transplantation concept. The Department uses a tree transplanter to carry out the operations. Since 2010, the Department was able to transplant 3131 trees in 8 districts of Gujarat including 2137 in the Gandhinagar district. The average cost of transplanting using the machine along with basic fertilizer and labor cost comes to around Rs. 4,580 per tree for the forest department excluding the cost of machinery. The total cost of Rs. 3,89,300 was incurred in translocation of 85 trees. A Composite Tree Transplanter machine mounted on a heavy truck chassis which perform pit digging, uprooting tree keeping its root stocks and earth ball intact, transplanting at new site and filling the pit with dug up soil; has been used for tree transplanting by the department.

District-wise abstract of Tree Transplanting is presented in annexure-1 at sl. no. 4.
According to certain estimates of the department, the state has been successful in achieving survival rates as high as 85% more recently. The best suitable period for transplanting experienced by the State was:-

Sl. No.	Period	Suitability	Remarks
1	April to June	Adverse	Due to hot season.
2	July to August	Most-Suitable	However, rainy season affects movement of machine.
3	September to March	Suitable	-

The key learning from the experience in the state include the following-

- ✓ Species with good coppicing power has better chances of survival. For example, ***Cassia species, Sapindus emarginatus, Azadirachta indica, Milletia, Emblica officinalis***
- ✓ Survival rates depend on Diameter at Breast Height (DBH) of trees:
  - < 20 cm DBH - Fairly good chance.
  - 20-30 cm DBH - Some chance
  - > 30 cm DBH - Rare chance
- ✓ Proper moisture regime is required for 2 years.
- ✓ Moist climate is conducive for tree transplanting
- ✓ Large Machine movements are restricted on highways.
- ✓ Machine limitations
  - Cannot work on hard surfaces
  - Big trees cannot be transplanted
  - Special maintenance care is required
  - Skilled operator is required

In the year, **2018-19**, *Peltophorum pterocarpum* (Peeli Gulmohar), *Pongamia pinnata* (karanj), *Holoptelea integrifolia* (kanji), Parakhiya, *Delonix regia* (gulmohar) and *Samanea saman* (Rain tree) were translocated 5 km away from uprooting site at Chiloda, Gandinagar. The diameter range of trees during uprooting was 23-70 cm. The survival of trees was 50% after one year of planting. *Cassia fistula* (Amaltas) of 10-20 cm diameter range was planted 5 km away from uprooting site to PWD Road, Gandhinagar in **2010**. The survival of trees was 95% after one year of planting. Same species of the same diameter range were planted in **2011** and their survival was 59% after one year of planting. *Cassia fistula* (Amaltas), *Azadirachta*

indica (Neem), *Tamarindus indica* (Imli), *Pongamia pinnata* (Karanja) and *Ficus religiosa* (Peepal) of the same diameter range were planted in various roads of Gandhinagar in 2012.

Gujarat experience suggests that species with good coppicing ability such as *Cassia species, Sapindus emarginatus, Azadirachta indica, Milletia, Emblica officinalis* has better chances of survival.

The details of survival of trees is presented in *Annexure-1 at sl no. 4.*

2.5 Haryana

The biggest-ever tree transplantation exercise in the country, over 5700 fully grown trees were transplanted to build Dwarka Expressway. The National Highways Authority of India (NHAI), which was building the road, had been given 90 days to transplant and fell trees in this 4.5 km stretch. The NHAI spent around Rs 30,000 for transplanting one tree and the authority has earmarked Rs. 70 crore for transplantation project. JCB, Crane with loader, Pit Digger were used during tree translocation.

Methodology adopted:

The soil around the tree is dug into 1.5 to 2 feet deep. The tree is pruned and a chemical solution is sprayed on the tree and the soil around it. The area is again dug, the stems are treated and left to grow for a few days before the final extraction and plantation to another spot, they added.

Ficus religiosa (peepal) and *Ficus verens* (pakad) of 20-80 cm diameter were planted in **2014** at Dusshera ground, Faridabad. The survival of trees was found 100% after one year of transplantation. At Badarpur area, both the species were planted in **2010**. At the time of uprooting, diameter range of the trees was 10-30 cm. The survival of trees was 90% after four years of transplantation. At the site, Plot 60 Gurgoan (along Aravali), Fish tail palm, *Ficus religiosa* (peepal), *Morus alba* (mulberry) and *Ficus recemosa* (bargad) were transplanted in **2010**. At the time of uprooting, diameter range of trees was 20 - 40 cm. Transplantation was done within 1 km.

The recorded survival of trees varied from 90 to 100% between one to four years of transplantation at above three sites.

The details of survival of trees are presented in *Annexure-1 at sl no.5.*

2.6 Jharkhand

- According to a consolidated report of tree felling and their transplantation in different section of national highways of Jharkhand as reported by Office of the Regional Chief Conservator of Forest, Ranchi, Jharkhand in **2019**. Total of 93,838 trees were decided to be felled and out of which 14,528 trees were recommended by HPC (High powered Committee) to be transplanted. It was noted that 6340 trees were transplanted but the reported survival was 1.64% %, i.e., 104 trees only.

- A report of DFO Hazaribagh East Division, Jharkhand dated 01/06/2018 states that 150 trees were transplanted but could not survive and almost all of them died, (Anon, 2018).
- Another review meeting of "High Powered Committee" of Forest Department, Jharkhand in 2018 (formed by the order of the Hon. High court of Ranchi, Jharkhand); made the following observations, for Jharkhand-

  Transplantation of 38 trees by JUIDCO (Jharkhand Urban Infrastructure Development Company Limited) on the bank of river Harmu Karam Bridge in August 2017 were found to be dead in September 2017. All 6 trees were transplanted near sewerage plant (near Kusai Colony) in the August 2017, were found dead after transplantation. The Ficus Spp. tree was also found dead after transplantation.

- NHAI did transplantation of 1000 trees in East Singhbhum and only 10-12% of trees transplanted survived. Also, report dated 15-06-2018 of Jharkhand Forest Department for "Transplantation" done by NHAI for NH33, which is close to Hazaribagh town in Jharkhand shows that the survival percentage is very poor. Rather this can be classified as "Failure". None of the "guidelines" issued for transplanting have been followed by NHAI; which includes neither following the desired "protocol"; nor timing of operations, (Anon, 2018).

Translocation of *Acacia spp.* and *Eucalyptus spp.,* was carried out in 2017 in Nagri (RIADA) and *Tectona grandis, Dalbergia sissoo, Polyalthia longifolia* and *Mangifera indica* in Patratu (NTPC) in 2018 by Volvo agency. The diameter range of *Acacia spp., Eucalyptus spp., Tectona grandis, Dalbergia sissoo* and *Polyalthia longifolia* during uprooting was 34 to 90 cm while diameter of *Mangifera indica* was 50 cm. In the first year of transplanting, the survival of trees was in the range of 50-100%. Maximum survival of 100% was observed in *Mangifera indica* (Aam) followed by *Tectona grandis* (80%), *Eucalyptus spp.* and *Dalbergia sissoo* (Shisham) (60%) and *Polyalthia longifolia* (Ashoka) (50%) in descending order. But in the second year, the survival of *Acacia spp.* was 30%, Eucalyptus (30%), *Tectona grandis* (40%), *Polyalthia* (40%) and only 02% of Shisham trees were found survived and none of the mango trees was found survived. The survival data of third year onwards is not available.

The State has reported ***decline in the survival*** of transplanted trees from second year onwards from the experience of Hazaribagh, Patratu and Nagri highways (NH 33) expansion.

The details are presented in *Annexure-1 at sl. no. 6.*

2.7 Karnataka

As per the experience of the Forest department which has transplanted about 457 trees from May to **August, 2017** involving 14 species, some tree species have responded promisingly and some have not.

Azadirachta indica (neem), *Albizzia lebbeck* (kala siris*), Holoptelea integrifolia* (kanju), *Zizyphus jujube* (ber), *Samanea saman* (rain tree) trees were translocated at NH 63 Dundur to Asundi Cross by Prashant Associates. The diameter range of trees was 50 to 100 cm. After first year of planting, 40% trees were found survived and after second year, only 2% trees

were found survived. Trees of *Albizzia lebbeck* (kala siris), *Holoptelea integrifolia* (kanju), *Acacia nilotica* (babul), *Aegle marmelos* (bel), *Eucalyptus*, *Ficus tsjahela* (karal fig) and *Ficus benghalensis* (bargad) were transplanted at NH 63 to Harlapur Cross at a distance of 3 to 4 km. The diameter range of trees was 50 to 100 cm. Survival of trees after first and second years of planting was found to be 10%. *Ficus benghalensis* (bargad) trees were transplanted 8-10 km away at Bhshma Lake. The diameter range of trees was 50 to 100 cm. It was observed that 100% trees were found surviving after one and two years of planting. *Ficus benghalensis* (pipal) trees were translocated at RDPR University, Mahaveer Jain Goshale compound, Singatarayna Keri Tanda Smashana and DC office compound. The diameter range of trees was 50 to 100 cm and trees were translocated to 12-15 km away from uprooting site. It was found that in the first year, 50-80% trees were found survived and after 2 year of translocation, 30 to 68% trees were found survived. The cost of Rs. 9,000 per tree was incurred in translocation with a total amount of Rs. 41,0,4,000 spent on translocation of 456 trees. The trees were lifted by Crane and placed on truck for transportation.

The state also reported ***decreasing survival*** in *Azadirachta indica, Albezzia lebbeck, Holoptelia integrifolia, Acacia nilotica, Aegle marmelos, Zizyphus spp., Eucalyptus spp*. and *Ficus tsjahela*. Only *Ficus benghalensis* & *Ficus religiosa* have shown good survival after 2nd year of transplantation. The details are presented in *Annexure-1 at sl. no. 7.*

2.8 Maharashtra

The Zoo authority, Nagpur has shifted trees of *Mitragyna parviflora* (kaim), *Terminalia bellirica* (baheda), *Phoenix sylvestris* (khajur), *Diospyros melanoxylon* (tendu), *Soymida febrifuga* (rohina), *Dalbergia sissoo* (shisham), *Carthemus tinctorius* (kusum), *Terminalia arjuna* (arjun) and *Azadirachta indica* (neem). The spouting of shoots of all the species in the first and second year was noticed.

In **Gorewada zoo Nagpur**, Trees of 20-45 cm diameter range, maximum age 30 years, were translocated, within 1-3 kms, in **2017-18** by VE Commercial Vehicle Ltd. The cost of Rs. 6,000 per tree was incurred in translocation with a total amount of Rs. 28,74,000 spent on translocation of 479 trees. Volvo Tree Transplanter equipment was used during translocation.

During **2019-20**, **Pune Metro Corporation** translocated trees of 10 to 40 years old at Kothrud F.S. no. 120. The survival of the trees is presented in *Annexure-1 at sl. no.8*

In **2018**, 446 trees of different species were translocated at Forest Academy, Chandrapur, Maharasthra. The diameter range of trees during translocation was 10-135 cm. After 3 years of transplanting 88.34% trees were found survived. The cost of Rs. 22,195 per tree was incurred in translocation with a total amount of Rs. 98,98,970 spent on translocation of 446 trees. Volvo Tree Transplanter equipment was used during translocation.

Maharashtra reported ***zero survival*** in the first year of translocation in Gorewala Zoo Nagpur in 05 species out of 34 species *viz*; *Melia azedarach, Tamarindus indica, Cordia mixa, Ailanthus excelsa, Ficus virens* and in Pune Metro project, 11 species out of 19 species; *Azadirachta indica, Mangifera indica, Morinda pubescens, Cassia siamea, Ficus racemosa,*

Tectona grandis, Cordia dichotoma, Tamarindus indica, Vachellia nilotica, Syzygium cumini, Bauhinia racemosa.

While *Soymida febrifusa, Bauhinia racemosa***,** *Terminalia alata, Choloroxylon sweitiana, Grewia tilifollia, Anogeissus latifolia, Acacia leucophloea, Flacourtia ramonchii, Mitragyna parviflora, Acacia catechu, Albizia procera, Lagestroemia parviflora, Tectona grandis* and *Phoenix sylvestris* have shown ***good survival*** (more than 75 %) after 2nd year of transplantation in Gorewala Zoo Nagpur.

The species planted in different diameters range and their survival is presented in *Annexure-1 at sl. no. 8.*

2.9 Punjab

The National Highway Authority of India has translocated 673 trees of *Ficus spp., Chakrassia velutina, Alestonia scholaris, Terminalia arjuna* (Arjun), *Melia composita* (Drek), *Azadirachta indica* (Neem), *Polyalthia longifolia* (Ashok), Kaner, *Putranjiva roxburghii* (putranjiva), Bougain vellia, *Tectona grandis (*teak*)* etc. in **2019** at NH 95.

No species was found surviving after first year of transplantation (*Annexure-1, sl. no. 9*).

2.10 Tamil Nadu

The Research Wing of Tamil Nadu forest department has relocated 50 trees of each species of *Tamarindus indica* (Imli) and *Azadirachta indica* (Neem) of diameter range of 30-90 cm at Zone -1 and 2 of State Forest Institute in **2017-18**. After two years, 38% of trees were found survived.

The trees of Neem (55-120 cm dia), *Samanea saman* (130-280 cm), *Peltophorum pterocarpum* (95-180 cm) and *Delonix regia* (100-160 cm) were translocated at Perungalathur-Vandalur-Irumbuliur Highway Road by Research Wing of Tamil Nadu Forest Department in **2018-19**. After two years of transplanting, all trees of neem and *Samanea saman* were found dead, while the survival of *Delonix regia* was 100% followed by *Peltophorum* with 33%.

Nine trees of different species with diameter range of 90-280 cm were translocated at Waljabad-Sunguvarchatram-Kelecheri Road by Research Wing of Tamil Nadu Forest department in **2019-20**. Out of 9 species, *Tamarindus indica, Azadirachta indica* and *Millettia pinnata* were found dead after one year while maximum survival was found in *Phoenix* and *Lannea coromandelica* (100%), followed by Albizzia lebeck (33%) *Peltophorum pterocarpum (*20%), *Borassus flabellifer* (10%) and *Morida tinctoria* (9%) in descending order.

Seventeen (17) species of diameter range of 0-280 cm were transplanted at Waljabad-Sunguvarchatram - Kelecheri Road by Research Wing of Tamil Nadu Forest department in **2019-20**. Out of 17 species, *Milletia pinnata, Lannea coromandelica, Morida tinctoria, Peltophorum pterocarpum, Phoenix, Ficus religiosa, Albizzia lebbeck* and *Sapathodea campanulatum* have shown 100% survival after 1 year followed by *Millettia hortensis (78%), Samania saman (67%), Borassus flabellifer (61%), Azadirachta indica (43%), Kijelia africana (31%), Syzygium cumini (29%) and Tamarindus indica (27%)* of survival in descending order.

The Research Wing of the State forest department has attempted translocation since 2017-18 along NH 45 (Perungalathur-Vandalur-Irumbuliur Highway Road) & Waljabad-Sunguvarchatram-Kelecheri Road. ***100% survival*** was reported in 08 species *viz. Milletia pinnata, Lannea coromandelica, Morida tinctoria, Peltophorum pterocarpum, Phoenix, Ficus religiosa, Albizzia lebbeck* and *Sapathodea campanulata* out of 17 species translocated. While *Tamarindus indica, Samanea saman, Azadirachta indica* and *Millettia pinnata* were found ***dead after one year***. The details are given in *Annexure-1 at sl. no. 10.*

2.11 Uttar Pradesh

2.11.1 Tree translocation in Mathura:

During the year **2015-16**, *Ficus virens* (pakad), *Ficus benghalensis* (bargad), *Ficus religiosa* (peepal) and *Ficus racemosa* (gular) were translocated at **Ahilyaganj, Forest Block**, Mathura District. The diameter range of trees was 10-90 cm during translocation. After first year of planting, the survival percentage of trees was 49%, in the second year, the survival was 38% and in the third year, survival was 05 % which was reduced to 0% in the 4th year.

52 trees of *Ficus virens* (pakad), 40 trees of *Ficus benghalensis* (bargad), 48 trees of *Ficus religiosa* (peepal) and 11 trees of *Ficus racemosa* (gular) were translocated at **Farah Block**, Mathura in **2015-16**. The diameter range of trees was 0-90 cm and distance from uprooting to planting was 1-34 km. The cost of Rs. 45,774 per tree was incurred in translocation with a total amount of Rs. 1,16,72,370 spent on translocation of 255 trees. After first year of planting, 54% trees of all species were found survived. In second year, 42% of trees were survived, in third year, 22% trees and in 4th year, only 7% trees were survived (*Annexure-1 at sl no. 12*).

2.11.2 Tree translocation in Agra:

The trees of 15 species were translocated at Runkata Van block by Rohit Nursery, Agra during **2015-16**, within a distance of 10-15 km. Overall survival of the species transplanted is estimated as 59% after 5 year of transplantation. The cost of Rs. 20,418 per tree was incurred in translocation with the total amount of Rs. 85,95,978 was spent on translocation of 421 trees. The survival and other details of trees after 5 years of translocation are given in *Annexure-1 at sl no. 12*.

2.12 Uttarakhand:

In the **year 2017**, *Terminalia arjuna* (arjun), *Ficus virens* (pilkhan), *Dalbergia sissoo* (shisham), *Albizzia lebbeck* (siris), *Populus deltoides* (poplar), Kokat, *Syzygium cumini* (jamun), *Aegle marmelos* (bail) and *Tectona grandis* (teak) were uprooted and planted in IIM, Kashipur (SIDCUL Area). During transplanting, the diameter range of trees was 0-90 cm. The cost of Rs. 23,500 per tree was incurred in translocation with the total amount of Rs. 30,08,000 was spent on translocation of 128 trees. Trees were translocated manually.

The State reported ***100% survival*** at the end of three years for all 11 species translocated at IIM Kashipur (Sidcul area) during 2017-18

The details are presented in *Annexure-1 at sl. no. 11*.

B. Technique of Trees Translocation (Based on literature)

3.0 Although no species wise focused research is available on standardizing the techniques of tree translocation, however based on the survival of the translocated trees and encouraging success stories of translocation attempts made by various user agencies, the following step by step processes are widely accepted for taking up tree translocation.

3.1 Season of Transplanting:

- November and December are most favourable months for transplanting large trees. The rainy season is not recommended for this work, because it is not practical to keep lately transplanted large trees steady during that season.

- Transplanting may also be appropriate after the leaves of the selected tree fall but before the onset of severe winter conditions since the tree is naturally going in dormant stage.

- Some species may survive transplanting any time during the year when the ground is not freezing, but woody plants are preferably moved in the spring after the ground softens and before the buds on the trees begin to appear.

- The trees which are transplanted in growing season when shoot growth is at its peak, are mostly unsuccessful & lead to mortality eventually.

3.2 Destination Site for Translocation:

- The environmental requirements differ for each tree and shrub species. The destination site for transplanting should be chosen based on the requirement of light, moisture, soil pH, and wind exposure tolerance for the particular species.

- The selected site should have sufficient space keeping in mind the requirement of space for root and crown development of the mature tree of the chosen species, and not just the size of tree at the time of transplanting.

- The destination site should be tested for soil quality and also check the drainage quality of the site to provide ideal soil conditions to the tree/s being translocated there. Trees will not tolerate highly compacted soil, which should be broken up over a large area of the site as possible. Planting pits should be provided with drainage to allow effective percolation of water

- Availability of enough space around for carrying out translocation activity, the site should not be prone to land degradation factors such as erosion, landslides etc.

3.3 Treatment to the tree – Before Translocation:

General health, size, species, root system etc., of the tree should be assessed before deciding about its removal and transplanting. Only a good and promising tree should be considered. The pre-treatment to the tree should begin at least 5 to 7 days prior to actual removal of tree. One-meter deep trench has to be dug around the tree trunk at a distance of about 1.5 to 2.0 m from the tree trunk with a medium bucket JCB and water it continuously. Watering should be done in the trench only. The shape can be either Rectangular or Circular, as per local convenience. This will help to soften the soil and pre-condition the roots for mild exposure and displacement. Care should be taken to lift larger sized trees with bigger root balls so that more roots are encompassed to ensure better re-growth and early establishment. Root growth promoters can be used. The Antibacterial and Antifungal spray/solution can be used if any roots are exposed and found injured. Crown pruning or root pruning can be done depending on the species and local conditions. But care should be taken that the injury caused to the tree is minimum.

3.4 Pruning:

- Pruning may not be necessarily beneficial to the tree as it reduces the capability of the tree to build up reserves. However, for transporting the tree to new location the amount of pruning depends on the size of the root ball and plant canopy, health of the plant, and the species transplanted.
- During transplanting the diseased, broken and insect infected stems should be removed or trimmed suitably.
- Root pruning is sometimes required before transplanting a tree. Additional pruning may be required to balance the leaf area with the reduced size of the root system, but further pruning of deciduous trees should be postponed for at least one year after transplanting.
- The leaves should be trimmed before transplantation. Only after the appearance of fresh leaves the trees may be lifted with strong packing for translocation.
- Further to the cutting of roots, fresh root growth should be identified. Only, after the observation of fresh root growth, the transplantation should be planned. It should be ensured that the roots do not rot in the process.

3.5 Treatment at the receptor/transplanting site:

The receptor site should be selected in such a way that it is very close or almost similar to the original site conditions and the treatment should start at least 5 to 7 days prior to transplanting.

3.5.1 Planting Pit size: The dimensions of a planting pit are determined by the depth and firmness of the root ball. In general, the planting pit width should follow international practice at a minimum of 1.5 times the diameter of the root ball. The thumb rule is, the transplanted tree should have at least two feet extra space/radius in the pit, after its placing in the pit which helps the roots to establish in a well-treated, nutrient-rich, infection free soil.

3.5.2 Preparation of Pit: Trees will not tolerate highly compacted soil; hence soil working is

done on such soils for improvement of soil aeration over a large area. Planting pits should be provided with drainage also to allow effective percolation of water. This pit should be watered daily, proper drainage given and cut surfaces may be drenched with antifungal/antibacterial/anti-termite/dung slurry or solutions. After three days, the pit should be filled to a height of one meter (from bottom of the pit) with adequate good quality organic manure/vermi-compost/FYM and mother soil or good local soil. Mother soil is the soil from the original site of the target tree that is to be transplanted. This will help the transplanted tree to find a comfortable root zone. Then continue watering till last day but care should be taken to keep the soil well drained.

3.5.3 Refilling of soil: The soil dug out from the pit is the best suited backfill material. When digging, place the topsoil (the top 6-inch layer) in one pile and the subsoil in another. Refill the pit with subsoil followed by top soil with proper irrigation in between. Tamp the soil lightly, but do not tamp so heavily as to compact the soil. Water again to settle the topsoil.

3.6 Tree lifting/removal during Translocation: The tree can be marked for its orientation to East and West directions, so that a similar orientation is maintained (as far as possible) at the receptor site also. On the day of transplanting, the tree should be adequately padded at its trunk with gunny bags where the Crane will hold and lift from the top. The tree trunk should also be tied with good sized ropes at its trunk to enable it to lodge/lie on to the long vehicle/lorry. The soil has to be loosened further with a JCB and the ball of earth with a big mass of intact roots can be lifted. JCB will assist to free the roots by a little, gentle push from below and the Crane should lift the tree from the top. This will help the tree to free itself with minimum possible damage to roots. When the tree is freed from the soil, the roots and the soil ball should be immediately covered with wet gunny bags (or can be done after placing the tree on the vehicle). Then the tree is lifted up in the air and with the help of ropes, it can be laid to sleeping position with its roots and soil ball facing towards the engine. Smaller trees (less than 70 cm girth) can be transported in Lorries keeping them in vertical position.

3.7 Tree transporting: After the tree is loaded on to the vehicle, it should be tied to the vehicle at suitable points to keep it in good hold and position during travel. The roots and the soil ball should be constantly kept covered with wet gunny bags and watered to reduce the impact of exposure to sun and desiccation. The mother soil from the root zone should be loaded into the vehicle, covering the gaps so that the tree gets the required cushion during travel. This soil can be used for filling into the pit at the transplanting site. The tree branches can be tied, without breaking them, to enable smooth movement. The vehicle should move at such a speed which should not cause any injury to the tree. All the overhead cables/wires/obstacles should be kept free all along the route. The traffic police should facilitate smooth movement of the vehicle. The health officers and the Ambulance services should be kept at site at all times during the operation to attend any emergency.

3.8 Transit nursery for interim support of uplifted trees: Occasionally in certain cases where the receptor site is far away from project site, or for those tree species that do not have strong root system to support themselves, or in situations of extreme weather conditions, such

as drought or heavy rainfall, the trees are kept in transit nursery for recovery. Proper irrigation and nutrient management should be provided in the nursery to ensure adequate root growth and stability of uplifted trees. Trees may be moved to the permanent receptor site from the transit nursery at the appropriate time.

3.9 Tree Transplanting into pits:

3.9.1 **Planting in receptor site:** Tree should be properly placed (avoid tilting) and preferably in the same orientation similar to donor site.

3.9.2 **Removal of supporting material:** The gunny bag/cloth used for wrapping of root ball and other supporting materials should be removed from the planting hole prior to final back filling.

3.9.3 **Pruning of damaged parts:** Any branches damaged in transit should be properly pruned back to the nearest branch bark ridge.

3.9.4 **Root ball position in planting Pit**: The top surface of the root ball should not be below the surrounding soil surface after final placement of the tree. The bottom of the trunk flare should be at or above the finished grade.

3.9.5 **Refilling of soil**: The refill soil should be compacted firmly around the base to stabilize the tree, but the rest of the soil should be tamped only lightly. Water should be added to the root ball and the refill soil to bring the root ball to field capacity.

3.9.6 **Tree transplanting:**

Now, the tree has occupied almost one meter height in the pit leaving only one meter space above its trunk base (collar). Fill the pit with mother soil and already stored good soil to a height of about one meter above the ground level. Keep watering till good compaction is achieved. Now, there is one meter mother soil below the roots of the tree and another one meter above it. Over and above this, there is another one meter of good soil (above ground level). This will ensure providing proper balance/compaction to the tree.

3.10 Care of trees after Translocation

All newly transplanted trees should receive proper maintenance care in order to facilitate recovery of tree from the transplanting shock. The stress of tree can be observed immediately after transplanting or gradually after a period of time. Proper care after transplanting will help to assure survival and minimize stress and ensure a higher successful rate. Post care maintenance is a continuous process and required minimum for a period of 3 to 5 years or until the proper establishment of the tree.

3.10.1 **Watering:** Regular watering is important for proper root growth and establishment of the tree thereby to minimize susceptibility to stress. The frequency of watering depends on weather, drainage, soil type, planting season and tree species. Care should be taken to avoid water logging which causes root rot.

- After transplanting, copious watering is done.
- Too much or too little water after transplanting is a major cause of tree or shrub loss. The site should be thoroughly watered immediately after planting.

- Thereafter, the soil must be regularly monitored to prevent drying out.
- If rainfall is inadequate, the soil around the plant's roots should be deeply watered approximately every 10 -14 days.
- If unsure that the soil is drying, dig down 3 to 4 inches next to the plant. Wet soil at that depth verifies watering is not needed at that time.

3.10.2 **Mulching of transplanted tree:**

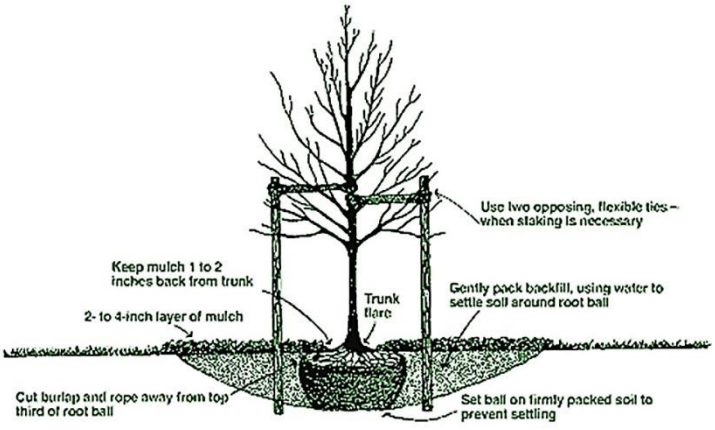
Mulch is a covering, as of straw, compost, or plastic sheeting, spread on the ground around plants to prevent excessive evaporation or erosion, enrich the soil, inhibit weed growth, etc.

- Mulches help conserve moisture, moderate soil temperature and control weeds around trees and shrubsand other competing vegetation, and to replenish organic matters and nutrients in the soil.
- They are placed on the soil surface over the tree or shrub root system. Either organic or inorganic mulches may be used.
- Organic mulches may be composed of bark or wood chips, straw, partially decomposed leaves or other materials. A bed of wood chips or other coarse organic mulch around a tree greatly increases root and tree health. Mulch should be free from pest and diseases.
- They should be applied 3 to 4 inches deep. Maintain a 4 to 6inches mulch-free area adjacent to the woody stemsto avoid root or trunk decay and rodent burrowing and damage.
- Inorganic mulches include crushed rock, woven fabric, and other materials. Should plastic mulches may impede or prevent root development because they do not allow air or moisture to move into or out of the soil from above?

3.10.3 **Staking of transplanted tree:**

Staking may help to retain a tree in an upright position until sufficient roots are developed to anchor the tree. Use canvas strapping or similar soft, flexible material around the tree to prevent trunk damage. Trees should be protected from bending due to wind by stakes. Stakes also help in transpiration of water.

- Transplanting is done when there is enough moisture in the soil. Hence, monsoon is the right time as enough moisture exists in the soil. September is the ideal month for carrying out the process of transplanting.
- Cold, moist and cloudy weather is the best for transplanting. The evenings are better suited for the purpose as plants refresh themselves in cool night.
- Soft-wooded species are better transplanted than hardwood species
- Remove the staking after 2 to 3 years.



3.10.4 **Nourishing and soil amendments:**

Application of fertilizer may be unnecessary unless nutrient deficiency is confirmed.

- Moderate release of nutrients by decomposition of both mulch and organic matter added to refill soil may be sufficient during the initial establishment period of transplanted tree.
- A fertilizer or manure should be mixed with the fill soil, as this could cause root damage.
- If transplants appear to need fertilizer during the first few years, a totally soluble complete fertilizer should be applied.

3.10.5 **Regular monitoring:**

Transplanted trees usually expose their stress by a kind of symptom. Therefore, regular or frequent monitoring of the transplanted tree is very much essential for precise diagnosis and management.

C. Different types of trees and their suitability for tree transplantation

4.0 Tree Transplanting is an old practice, which has been employed to rescue, save, or salvage certain trees, which are under threat of cutting or removal or damage due to various reasons. Such trees which are under threat and which also assume importance due to their rarity of occurrence, species type, endangered status, size, age, location, religious importance, medicinal value, emotional value, aesthetic value, etc., can be considered for Transplanting.

4.1 **Preference to native species:** Though hundreds of species are used in the urban environment, hardy native species like *Ficus benghalensis, Ficus religiosa, Pongamia pinnata, Zizyphus mauritiana, Terminalia arjuna, Syzygium cumini, Mangifera indica, Artocarpus hirsutus* etc., having faster recovery are preferred over exotic species.

4.2 Survival of translocated trees is dependent on species. The data showed that *Ficus spp., Dalbergia sissoo* (shisham), *Cassia fistula* (amaltas), *Holoptelea integrifolia* (kanju), *Peltophorum pterocarpum (*pila gulmohar*), Terminalia arjuna (*arjun*), Delonix regia (*gulmohar*), Albizzia lebbeck* (siras*), Phoenix sylvestris (khajur), Lannea coromendelica, Spathodea campanulata, Syzygium cumini (*jamun*), Aegle marmelos (Bel), Acacia nlotica (babul), A. lecophloea (Reonz), Pongamia pinnata (Kanji), A. catechu (*khair*)* and *Tectona grandis* (teak) have shown more than 50% survival after two years of translocation. The tree **species which produce coppice shoots** have better chances of survival after translocation if proper care is taken.

The species which are found promising also as per the experiments done in the states are *Tabubia spp, Butea monosperma, Bombax sp, Psidium guajava, Sapindus spp, Nyctanthus arbortristis, Moringa oleifera, Tecomella undulata, Pongamia pinnata, Justicia adhathoda*,

4.3 **The size of the tree:** The survival of **mature and over mature trees** of more than 70 cm diameter is found to be less in comparison to the trees of lower diameter class. Young trees experience less root loss when transplanted, they establish themselves more quickly, usually overtaking their larger counterparts after just a few years. Larger trees need bigger root ball to encompass more roots to ensure adequate re-growth, as well as anchorage and stability. Generally, larger and older a tree, the more difficult it is to transplant successfully. Trees with a DBH of over 25 cm will incur significantly higher costs, trees with a DBH of over 50 cm will incur very high costs and trees with a DBH of over 70 cm should rarely be considered feasible for transplantation. Transplanting may not be recommended in cases where a reasonable root ball size cannot be achieved.

4.4 The survival rate is also not very encouraging in **higher diameter class**. As the trees are halfway through their rotation the curve of growth rate tends to flatten and as they reach maturity (i.e. the age of culmination of CAI & MAI), the growth rate either tends to go stagnant or declining. Transplanting may not be recommended in such cases.

4.5 **The health of the tree:** If the tree is already in poor health condition it is highly unlikely to withstand the stress of transplantation. Structural defects like decay, hollowness, crooked shape

etc. at the primary locations on the trunk have adverse bearing on the survival rate of tree translocation.

4.6 **Species specific survival rate**: Some species are much more tolerant to the stress of transplantation than others. The assessment of the survival rate of a species after transplantation is based on the observed performance of that particular species in previous transplantation programmes. Species with insufficient transplantation data of the past cannot be assumed to have a good survival rate. The survival of trees varies between states/agencies and sites as well as across the species transplanted.

4.7 **Feasibility of root-ball preparation:** Site topography, the proximity of above and below ground utilities and whether the tree is crowded by other trees are all major factors determining the feasibility of preparing a sufficiently large root-ball for successful transplantation;

i) **Root Extent:** A tree growing in rocky ground, surrounded by hard paving or which is crowded by other trees is likely to have a distorted root system seriously reducing the feasibility of preparing a sufficiently large root-ball for successful transplantation;

ii) **Accessibility:** Accessibility of the site should be considered including the movement and set up of the transplanting equipment and the manoeuvrability of the operation machinery and vehicles. Large machinery is required to lift trees, so steep slopes and rocky terrain drastically reduces the feasibility of successful transplantation. Moving **a tree with heavy crown**, out of or into a site involves lifting to a vehicle and limitation of the size of a vehicle or transport safety requirements. It is not recommended to significantly prune tree to fit in transport vehicles. Trees growing on slopes, retaining walls or areas where formation of a root ball of reasonable size is not feasible are considered not transplantable.

Digging a tree for transplanting can remove as much as 90 percent of the absorbing roots which causes transplant shock to the tree. A transplanted tree should be able to re-establish sufficient roots to sustain it. If the tree has **poor health**, the rates of survival and recovery will be low. Root pruning to form a reasonable size of root ball is required and may be adjusted to suit specific tree species. All cut roots shall be trimmed cleanly back to the healthy tissues to reduce the split and torn roots.

4.8 **Trees in containers:** Trees in containers are more resistant to root damage during transportation. This is a recommendable method of transplanting as the root ball is well protected and lifting of the boxed root ball during transplanting will give better protection during the transplanting operation and enhance better establishment of the tree afterwards.

4.9 **Tools and machines**: The requirements of tools and machines depend on size of the trees. The translocation can be carried out manually or with heavy machinery depending upon the size and number of trees to be transplanted/ translocated. The manual treatments and preparations to be undertaken prior to translocation are already explained at section 3 of this report.

D. The Feasibility of Successful Transplantation:

5.0 Based on the suitability of different trees for transplantation the feasibility of success can be graded as below-

5.1 **Feasible with standard costs –** Transplanting a young tree of smaller girth class & less crown density is deemed cost effective and is taken as standard. The standard cost may vary from State to State.

5.2 **Feasible with significant cost implications** –Transplanting an established or middle age tree having higher girth class (less than 90 cm), heavy crown density and elaborate root system is presumed to involve additional costs for tree preparation before, during & after transplantation. The cost implications may vary from tree to tree & species to species in this case.

5.3 **Not Feasible –** When the tree has multiple trunks or attains an over mature status (having completed its rotation period), having a deep and elaborate tap root system, or attains girth class over 90 cm; in such circumstances the transplantation/translocation is **NOT** feasible. If attempted the experiment is bound to promote slow death of an otherwise healthy tree.

III. DATABASE OF AGENCIES BOTH IN THE PUBLIC AND PRIVATE SECTORS AND HIGH-TECH TRANSPLANTING MACHINERY AVAILABLE FOR TREE TRANSPLANTATION

6.0 The preparation of Database of key agencies of Tree Translocation/ Transplantation was undertaken to enlist, assess, evaluate the numerical strength of the service providers in this field, the methodologies adopted by them, experience of these agencies in execution of tree translocation etc. For this purpose, applications for registration were invited from all the interested stake holders, with all the relevant details and documents. The registration was free of cost and open up to 30th June 2020 and the application form was available in official website of ICFRE/FRI at **www.icfre.org; www.fri.icfre.gov.in**

6.1 Based on the information and documents provided, the agencies/ service providers have been categorized in to Government / Private agencies (Annexure 4) and; based on the turnover the categories have been made as -

(a) Below 50 lakhs,
(b) 50 lakhs to 1 crore
(c) Above 1 crore

6.2 Machines, Tools and other Accessories - There are various machines and tools being used for tree translocation like – JCB, Crane, Truck with loader, pit digger etc. (Annexure-5). As per the report of the Committee constituted by Government of Uttar Pradesh, on the direction of Supreme Court in IA No.499-500 in Writ Petition No. (Civil) 13381/1984, DMRC had explored the machines like DAMCON tree transplanter KLR – 2M **(**www.damcon.nl) in the States of Haryana & Delhi; while Gujarat Forest Department has been using a composite tree transplanter machine mounted on a heavy truck chassis which performs pit digging, uprooting tree keeping its root stocks and earth ball intact, transplanting at new site and filling the pit with dug out soil. The machine has been imported from USA by Gujarat State Petronet Limited (GSPL) and handed over to GFD in July, 2010 under CSR (Corporate Social Responsibility). Tree transplanter is available in two models – 90 D & 100 D. The transplanter of 90 D can transplant the tree of basal diameter upto 30 cm where as 100 D can do transplanting of a tree having a basal diameter of 32 cm. It is also said that the trees having basal diameter above 32 cm are mature or over mature and the vigour for survival in over mature trees is less compared to the younger trees. *(Reported as per the site inspected by the committee in June 2014)*

6.3 Comparison between high-tech machines vs. JCB for tree transplantation- Tree transplantation is laborious task as it includes mechanized power for relocation of large trees. This process includes encircling the tree, digging into the ground and then lifting the entire tree, including its roots and soil out of the ground and replanting or transplanting the whole tree in the designated area. There are heavy machinery equipments available for such laborious tasks such as Tree spade which is specialized tools for transplantation. Often it includes a vehicle with a tilting mechanism, lifting mechanism and digging apparatus. The digging apparatus utilizes dual hydraulic cylinders to draw the digging into the soil surrounding the plant to be removed and transported. Digging apparatus comprises a frame and a plurality of blades. A dual cylinder attached to each of the blades and to the frame, when tree spades is

compared to JCB, it is found that the latter do not have specialized tools like tree spades [A typical machine consists of a number of blades (generally 3 or 4, but single or dual blade designs also exist)] while in JCB front and back attached shovel is specifically designed for digging the surface and for excavation purpose only. Its front mounted shovel can be used to hold the uprooted tree but horizontally and not vertically. Also JCB machines do not have such blades which can hold and grip the uprooted trees. It is said that success rate of transplanting by tree spade is the highest. However there is no prominent evidence found of transplantation from JCB as all the cases reported used tree spade for carrying out transplantation.

ANNEXURE-1

Data on survival of translocated trees in different States of India

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
1.	**Andhra Pradesh**	Benz circle, NH-16, Vijayawada, AP	AP Greeening & Beauti fication Corp.	*Terminalia mentalis, Mimusops elengi, Ficus religiosa, Azadirachta indica, Peltophorum ptrocarpum, Pongamia pinnata, Bauhinia variegata, Samanea saman, Albizia lebbeck, Delonix regia, Hibiscus, Tiliaceus, Sapindus emarginatus, Cordia dichotoma, Cassia fistula, Syzygium cumini*	272	40 to 170 cm	18 to 50 years	5 to 13 km	2017-18	81	76	-	-	-

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
2.	**Chandigarh**	City forest near Sukhna lake		*Bombax ceiba*	01	205 cm	Around 20 years	2 km	2020-21	100*	-	-	-	-
3.	**Delhi**	IIT Campus, Hauz khas	Rohit Nursery	*Alstonia*	31	20 to 40 cm	-	Within 01 km	2009-10	-	-	-	-	85
				Other species	14	10 to 30 cm	-							
		DDA park, Dhaula Kuwan	Rohit Nursery	Silver oak, Putranjeeva, Fish tail palm, Sirish, Bottle brush, *Ficus spp*., Arjun	150	10 to 30 cm	-	1 to 10 km	2008-09	-	-	-	-	85
4.	**Gujarat**	Chiloda Gandhinagar Sarkhej		Peltoforum, Karanj, Kanaji, Parakhiya, Gulmohar, Raintree		23 to 70 cm	-	0-5 km	2018-19	50	-	-	-	-
		PWD Road, Gandhinagar	Gujarat Forest Department	*Cassia fistula*	57	10 to 20 cm	-	5 km	2010-11	-	-	-	95	-
		Sector 8, Gandhinagar	Gujarat Forest Department	*Cassia fistula*	107	10 to 20 cm	-	2 km	2011-12	-	-	59	-	-
		Various road/ buildings, Gandhinagar	Gujarat Forest Department	Amaltas, Neem, Tamarind, Milletia, Peepal	74	10 to 20 cm	-	Upto 2 km	2012-13	-	65	-	-	-
5.	**Haryana**	Dussehra ground, Faridabad	Rohit Nursery	*Ficus religiosa*, *Ficus virens*	08 01	20 to 80 cm	-	1.5 km	2014-15	100	-	-	-	-

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
		Badarpur elevated corridor area near fly over	Rohit Nursery	*Ficus religiosa, Ficus virens*	31	10 to 30 cm	-	Within 01 km	2010-11	-	-	-	90	-
		Plot-60, Gurgaon (Along aravali)	Rohit Nursery	Fish tail palm, Peepal, Mulberry, Bargad	03 03 07 01	20 to 40 cm	-	Within 01 km	2014-15	100	-	-	-	-
6.	**Jharkhand**	Nagri (RIADA)	Volvo Agency	*Acacia sp.*	118	40 to 90cm	15/20 (approx.)	5 to 6km	2018-19	50	30*	-	-	-
				Eucalyptus sp.	10	40 to 90cm	15/20 (approx.)	5 to 6km		60	30*	-	-	-
		Patratu (NTPC)	Volvo Agency	*Tectona grandis*	611	40 to 90cm	20/25 (approx.)	< 10km	2018-19	80	40*	-	-	-
				Dalbergia sissoo	26	40 to 60cm	10/15 (approx.)	< 10km		60	02*	-	-	-
				Polyalthia longifolia	11	40 to 90cm	5/10 (approx.)	< 10km		50	40*	-	-	-
				Mangifera indica	01	50cm	5 (approx.)	< 10km		100	00*	-	-	-
7.	**Karnataka**	NH 63 Dundur to Asundi Cross.	*Prashant Associates*	*Azardirechta indica*	456	50 to 100 cm	15	3 to 4 Km	2018-19	40	02*	-	-	-
				Albezzia lebbeck,										
				Holoptelea integrifolia										
				Acacia nilotica,										
				Ziziphus jujube										
				Rain tree										
		NH 63 Lakkundi to Harlapur		*Azardirechta indica*		50 to 100 cm	15	3 to 4 km	2018-19	10	10*	-	-	-

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
		Cross		*Albezzia lebbeck,*										
				Holoptelea integrifolia										
				Acacia nilotica										
				Aegle marmelo										
				Eucalyptus										
				Ficus tsjahela										
				Ficus benghalensis										
		Bhishma Lake		*Ficus benghalensis,*		50 to 100 cm	20 to 25	8 to 9 km	2018-19	100	100*	-	-	-
				Ficus religiosa										
		RDPR University		*Ficus benghalensis*		50 to 100 cm	Around 20 years	12 Km		80	68*	-	-	-
		Mahaveer Jain Goshale Compound		*Ficus benghalensis*		50 to 100 cm	Around 20 years	15 Km		60	47*	-	-	-
		Singatarayana Keri Tanda Smashana		*Ficus benghalensis*		50 to 100 cm	Around 20 years	15 Km		60	47*	-	-	-
		DC Office Compound		*Ficus benghalensis*		Less than 50 to 100 cm	Around 20 years	15 Km		50	30*	-	-	-
8.	**Maharashtra**	Gorewada Zoo, Nagpur	VE Commercial Vehicle Ltd.	*Terminalia arjuna*	27	20-45 cm	Max age of tree 30 years	1 to 3 km	2017-18	78	78	-	-	-
				Bauhinia racemosa	02					100	100	-	-	-
				Terminalia alata	05					80	80	-	-	-

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
				Cassia fistula	07					57	57	-	-	-
				Melia azedarach	02					00	00	-	-	-
				Terminalia bellirica	07						57	-	-	-
				Choloroxylon sweitiana	09					100	78	-	-	-
				Ziziphus xylopyrus	02					50	50	-	-	-
				Buchanania lanzan	04					50	50	-	-	-
				Albizia odoratissima	07					57	57	-	-	-
				Tamarindus indica	01					00	00	-	-	-
				Grewia tilifollia	07					100	100	-	-	-
				Anogeissus latifolia	23					83	83	-	-	-
				Dalbergia latifolia	04					50	50	-	-	-
				Gardenia Turgida	03					67	67	-	-	-
				Cordia mixa	01					00	00	-	-	-
				Acacia leucophloea	02					100	100	-	-	-
				Azadirachta indica	17					29	29	-	-	-
				Flacourtia ramonchii	08					88	88	-	-	-
				Mitragyna	15					87	87	-	-	-

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
				parviflora										
				Anogeissus pendula	41					68	68	-	-	-
				Acacia nilotica	01					100	100	-	-	-
				Acacia catechu	05					100	80	-	-	-
				Albizia procera	05					80	80	-	-	-
				Lagestroemia parviflora	08					88	88	-	-	-
				Ailanthus excelsa	01					00	00	-	-	-
				Ficus virens	01					00	00	-	-	-
				Soymida febrifusa	120					88	88	-	-	-
				Tectona grandis	02					100	100	-	-	-
				Dalbergia sissoo	23					09	09	-	-	-
				Gmelina arborea	10					90	70	-	-	-
				Phoenix sylvestris	100					99	90	-	-	-
				Diospyros melenoxylon	08					50	50	-	-	-
				Ficus racemosa	01					100	100	-	-	-
		Kothrud F.S. No. 120	Pune Metro Corp.	*Ficus religiosa*	32	50 to 190 cm	10 to 40	-	2019-20	06*	-	-	-	-
				Ficus	26	50 to 190	10 to 40	-		19*	-	-	-	-

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
				benghalensis		cm								
				Azadirachta indica	35	60 to 150 cm	10 to 20	-		00*	-	-	-	-
				Unknown	12	40 to 130 cm	10 to 15	-		42*	-	-	-	-
				Mangifera indica	08	50 to 120 cm	10 to 30	-		00*	-	-	-	-
				Morinda pubescens	02	30 to 70 cm	10 to 25	-		00*	-	-	-	-
				Millingtonia hortensis	15	40 to 90 cm	10 to 25	-		47*	-	-	-	-
				Saraca asoca	08	20-90 cm	10 to 25	-		38*	-	-	-	-
				Cassia siamea	16	30-80 cm	10 to 30	-		00*	-	-	-	-
				Ficus racemosa	14	50-90 cm	10 to 35	-		00*	-	-	-	-
				Aegle marmelos	04	30-80 cm	10 to 20	-		25*	-	-	-	-
				Tectona grandis	01	50-80 cm	15 to 30	-		00*	-	-	-	-
				Cordia dichotoma	18	60-80 cm	20 to 30	-		00*	-	-	-	-
				Cassia fistula	04	50-90 cm	20 to 30	-		25*	-	-	-	-
				Tamarindus indica	05	30-60 cm	20 to 30	-		00*	-	-	-	-
				Vachellia nilotica	10	50 -130 cm	20 to 40	-		00*	-	-	-	-
				Delonix regia	12	40-90 cm	15 to 30	-		58*	-	-	-	-
				Syzygium cumini	17	60-120 cm	25 to 40	-		00*	-	-	-	-
				Bauhinia racemosa	02	40-70 cm	15 to 35 year	-		00*	-	-	-	-
		Compartment No	Forest	*Tectona*	292	15-120 cm	Age	-	2018-19	95	90*	-	-	-

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
		403 Forest Academy, Chandrapur	Academy, Chandrapur	*grandis*			varies from 15 to 35 years							
				Mangifera indica	1	61-75 cm		-					-	-
				Bauhinia racemosa	1	61-75 cm		-					-	-
				Saraca asoca	10	15-90 cm		-					-	-
				Bahada	2	26-45 cm		-					-	-
				Behada	1	106-120 cm		-					-	-
				Albizia odoratissima	4	46-105 cm		-					-	-
				Tamarindus indica	2	36-60 cm		-					-	-
				Giripushpa	2	36-60 cm		-					-	-
				Haldu	1	46-60 cm		-					-	-
				Hardoli	1	46-60 cm		-					-	-
				Jambhul	1	121-135 cm		-					-	-
				Kadunimb	22	10-120 cm		-					-	-
				Karanj	1	46-60 cm		-					-	-
				Albizia procera	1	61-75 cm		-					-	-
				Moha	1	76-90 cm		-					-	-
				Parad	3	36-60 cm		-					-	-
				Peltaforum	1	121-135 cm		-					-	-
				Lagerstroemea parviflora	1	61-75 cm		-					-	-
				Gmelina arborea	3	15-60 cm		-					-	-
				Dalbergia sissoo	6	61-90 cm		-					-	-
				Surya	87	15-90 cm							-	-
				Tembhumi	2	15-135 cm							-	-

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
9.	**Punjab**	NH95	NHAI	Ficus spp., Chakrassia, Alestonia, Arjun, Drek, Neem, Ashok, Kaner, Putranjiva, Bougain vellia, *Tectona grandis* etc.	673				2019	00	-	-	-	-
10.	**Tamil Nadu**	Zone-1: State Forest Research Institute Chennai	Research wing of Tamil Nadu Forest Department	*Tamarindus indica*	50	30-90 cm	7-12	100-200 M	2017-18	52	42	38*	-	-
		Zone-2: State Forest Research Institute Chennai		*Azadirachta indica*	50	30-90 cm	7-12	100-200 M	2018-19	42	38*	-	-	-
		Perungalathur-Vandalur-irumbuliur Highway Road: State Forest Research Institute, Chennai	Research wing of Tamil Nadu Forest Department	*Azadirachta indica*	14	55-120 cm	7-20	7 Km	2018-19	7.14	0	-	-	-
				Samanea saman	10	130-280 cm	5-15			60	0	-	-	-
				Peltophorum pterocarpum	30	95-180 cm	5-15			83.33	33.33*	-	-	-
				Delonix regia	03	100-160 cm	5-10			100	100*	-	-	-
		National Highway NH-45 - Irumbulyur to Vandalur: State	Research wing of Tamil Nadu Forest Department	*Delonix regia*	08	41-61 cm	2-60	1 Km	2019-20	75	-	-	-	-
				Azadirachta indica	01	147 cm	20			0	-	-	-	-
				Millingtonia hortensis	01	63 cm	10			100*	-	-	-	-
				Lannea coromandelica	01	108 cm	20			100*	-	-	-	-

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
		Walajabad - Sunguvarchatram - Kelecheri Highway Road (07-11 Km): State Forest Research Institute, Chennai	Research wing of Tamil Nadu Forest Department	*Borassus flabellifer*	76	90-280 cm	20-60	5-27 Km	2019-20	77.63*	-	-	-	-
				Tamarindus indica	27	90-280 cm	10-30	5-27 Km		96.29*	-	-	-	-
				Azadirachta indica	31	90-280 cm	10-30	5-27 Km		87.09*	-	-	-	-
				Morida tinctoria	11	40 cm	3	5-27 Km		9.09*	-	-	-	-
				Millettia pinnata	10	86 & 170 cm	15-25	5-27 Km		50*	-	-	-	-
				Albizia lebbeck	03	90-280 cm	5-30	5-27 Km		100*	-	-	-	-
				Peltophorum pterocarpum	05	90-280 cm	5-15	5-27 Km		80*	-	-	-	-
				Phoenix sylvestris	02	250 cm	5	10 Km		100*	-	-	-	-
				Lannea coromandelica	01	200 cm	5	10 Km		100*	-	-	-	-
		Walajabad - Sunguvarchatram - Kelecheri Highway Road (0-3 Km): State Forest Research Institute, Chennai	Research wing of Tamil Nadu Forest Department	*Millettia hortensis*	23	0-90 cm	1-3	5-21 Km	2019-20	78.26*	-	-	-	-
				Millettia pinnata	04	0-30 cm	1-2	5-21 Km		100*	-	-	-	-
				Azadirachta indica	58	0-280 cm	2-40	5-21 Km		43.10*	-	-	-	-
				Syzygium cumini	14	90-280 cm	2-40	5-21 Km		28.57*	-	-	-	-
				Samanea saman	06	0-200 cm	2-30	5-21 Km		66.66*	-	-	-	-
				Lannea coromandelica	06	31-280 cm	2-50	5-21 Km		100*	-	-	-	-
				Borassus flabellifer	59	60-280 cm	30-60	5-21 Km		77.96*	-	-	-	-

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
				Tectona grandis	02	72 cm	3-5	5-21 Km		0	-	-	-	-
				Morida tinctoria	02	34 & 65 cm	2-4	5-21 Km		100*	-	-	-	-
				Peltophorum pterocarpum	05	31-200 cm	2-6	5-21 Km		100*	-	-	-	-
				Phoenix sylvestris	01	90 cm	30	5-21 Km		100*	-	-	-	-
				Albizia lebbeck	03	31-280 cm	4-20	5-21 Km		100*	-	-	-	-
				Spathodea campanulata	03	31-90 cm	1-2	5-21 Km		100*	-	-	-	-
				Terminalia catappa	01	60 cm	1	5-21 Km		00	-	-	-	-
				Kigelia africana	13	91-280 cm	5-50	5-21 Km		30.76*	-	-	-	-
				Ficus religiosa	01	182 cm	30	5-21 Km		100*	-	-	-	-
				Tamarindus indica	26	91-280 cm	5-30	5-21 Km		26.92*	-	-	-	-
11.	**Uttarakhand**	IIM, Kashipur (SIDCUL Area)	Rohit Nusrery	Arjun	79	30-60 cm 60-90 cm	-	3-4 km	2017-18	100	100	-	-	-
				Aam	06	30-60 cm	-	5-10 km						
				Pilkhan	02	0-30 cm	-	5-10 km						
				Shisham	07	0-30 cm	-	5-10 km						
				Kokat	05	0-30 cm	-	5-10 km						
				Shagaun	10	30-60 cm	-	5-10 km						
				Sirus	07	30-60 cm	-	5-10 km						
				Jamun	01	0-30 cm	-	5-10 km						
				Poplar Poplar	09	0-30 cm 30-60 cm	-	5-10 km 5-10 km						
				Bail	01	0-30 cm	-	4-5 km						
				Dhaak	01	0-30 cm	-	4-5 km						

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
12.	**Uttar Pradesh**	Ahilyaganj Forest Block (Mathura)	Rohit Nursery	*Ficus virens*	25	20-70 cm	-	12-53 Km	2015-16	49	38	05	00	-
				Ficus benghalensis	26	10-80 cm	-	8-44 km						
				Ficus religiosa	53	10-90 cm & above	-	8-78 km						
		Farah Forest Block (Mathura)	Rohit Nursery	*Ficus virens*	52	10-90 cm & above	-	1-33 km	2015-16	54	42	22	07	-
				Ficus benghalensis	40	10-90 cm & above	-	3-34 km						
				Ficus religiosa	48	10-80 cm	-	2-31 km						
				Ficus racemosa	11	0-50 cm	-	2-29 km						
		Runkata Van Block, Agra	Rohit Nursery	Shisham	63	0-40 cm	-	10-15 km	2015-16	91.38	-	63.87	62.82	62.82*
				Pakhad	89	0-60 cm	-			81.53	-	77	33.81	33.81*
				Peepal	75	0-60 cm	-			89.27	-	70.93	64.50	64.50*
				Gulmohar	38	0-60 cm	-			72.30	-	67.54	28.65	28.65*
				Kath Sagaun	02	20-30 cm	-			100	-	100	100	100*
				Gular	27	0-50 cm	-			55.76	-	34.09	14.09	14.09*
				Amaltas	08	0-20 cm	-			83.33	-	66.67	58.33	58.33*
				Bargad	43	0-40 cm	-			73.81	-	68.77	48.44	48.44*
				Papdi	27	0-50 cm	-			97.22	-	83.33	56.94	56.94*
				Subabul	02	10-20 cm	-			100	-	100	100	100*
				Kanji	50	0-30 cm	-			93.94	-	84.55	80.38	80.38*
				Peltafarm	01	20-30 cm	-			100	-	100	100	100*
				Siras	01	10-20 cm	-			00	-	00	00	00*
				Rubber Plant	01	10-20 cm	-			100	-	00	00	00*
				Godani	01	10-20 cm	-			100	-	100	00	00*
13.	**Tripura**	**NIL**												
14.	**Himachal Pradesh**	**NIL**												

S. No.	State	Name of site/ locality	Name of Agency	Species transplanted	No. of trees	Diameter (Species wise)	Age of tree (years)	Distance	Year of trans-plantation	Survival Percentage				
										1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
15.	**Madhya Pradesh**	**NIL**												
16.	**Meghalaya**	**NIL**												
17.	**Kerala**	**NIL**												

(** Survival of Trees in 2020-21)*

ANNEXURE-2

The favourable species (based on survival >50%) for transplanting

Sr. No.	Species transplanted	Diameter Range (cm)	Year of Transplantation	Survival Percentage				
				1st Yr	2nd Yr	3rd Yr	4th Yr	5th Yr
1.	*Dalbergia sissoo*	0-30	2017-18	100	100	100	-	-
			2015-16	91.38	-	63.87	-	-
2.	*Ficus religiosa*	0-190	2018-19	100	100	-	-	-
			2017-18	81	76	-	-	-
			2015-16	89.27	-	70.93	64.50	64.50
			2014-15	100	-	-	-	-
			2012-13	-	65	-	-	-
			2010-11	-	-	-	90	-
3.	*Cassia fistula*	0-60	2017-18	57	57	-	-	-
			2017-18	81	76	-	-	-
			2015-16	83.33	-	66.67	58.33	58.33
			2012-13	-	65	-	-	-
			2011-12	-	-	59	-	-
			2010-11	-	-	-	95	-
4.	*Ficus benghalensis*	0-130	2015-16	73.81	-	68.77	48.44	48.44
			2014-15	100	-	-	-	-
5.	*Holoptelea integrifolia*	0-160	2018-19	50	-	-	-	-
			2015-16	97.22	-	83.33	56.94	56.94
			2015-16	93.94	-	84.55	80.38	80.38
6.	*Peltophorum pterocarpum*	60-70	2018-19	50	-	-	-	-
			2017-18	81	76	-	-	-
			2015-16	100	-	100	100	100
7.	*Terminalia arjuna*	20-90 cm	2017-18	78	78	-	-	-
			2017-18	100	100	100	-	-
8.	*Delonix regia*	40-90 cm	2019-20	58	-	-	-	-
			2018-19	50	-	-	-	-
			2017-18	81	76	-	-	-
9.	*Azadirachta indica*	10-20 cm	2017-18	81	76	-	-	-
			2012-13	-	65	-	-	-
10.	*Pongamia pinnata*	23-70 cm	2018-19	50	-	-	-	-
			2017-18	81	76	-	-	-
11.	*Samanea saman*	23-70 cm	2018-19	50	-	-	-	-
			2017-18	81	76	-	-	-
12.	*Albizia lebbeck*	30-60 cm	2017-18	81	76	-	-	-
			2017-18	100	100	100	-	-
13.	*Syzygium cumini*	0-30 cm	2017-18	81	76	-	-	-
			2017-18	100	100	100	-	-
14.	*Ficus virens*	0-80 cm	2017-18	100	100	100	-	-
			2014-15	100	-	-	-	-
			2010-11	90	-	-	-	-
15.	*Tectona grandis*	20-60 cm	2017-18	100	100	-	-	-
			2017-18	100	100	100	-	-
16.	*Phoenix sylvestris*	30-80 cm	2017-18	100	99	90	-	-

ANNEXURE- 3

Keeping in view the heavy cost involved in tree translocation, the suggestive list of most favourable species for translocation is tabulated below:

(*Based on data showing more than 80% survival after 2 years of transplantation of these species*)

Sl. no.	Species transplanted	Diameter Range (cm)	Year of Transplantation	Survival % after 2 years	
				1st Yr	2nd Yr
1	*Dalbergia sissoo*	0-40	2017-18	100	100
2	*Ficus religiosa*	40-182	2019-20 2018-19	100 100	- 100
3	*Ficus benghalensis*	50-100	2018-19	100	100
4	*Ficus virens*	0-80	2017-18 2014-15	100 100	100 -
5	*Peltophorum pterocarpum*	20-30	2015-16	100	100
6	*Terminalia arjuna*	30-90	2017-18	100	100
7	*Albizzia lebbeck*	30-60	2017-18	100	100
8	*Syzygium cumini*	0-30	2017-18	100	100
9	*Tectona grandis*	30-60	2017-18	100	100
10	*Delonix regia*	40-170	2017-18	100	100
11	*Phoenix sylvestris*	30-80	2017-18	100	99
12	*Cassia fistula*	10-20	2010-11	100	95

In majority of tree translocation cases it is observed that trees with less than 70 cm diameter are found to have better survival as compared to trees with higher diameter class. Younger trees experience less root loss when transplanted; hence they show better resilience to transplantation shock. The above 12 species are also found to respond differently to translocation in different parts of the country. The above mentioned species are also good coppicers. The zone-wise species are listed below:

Sl. no.	Species name	Zones
1.	*Dalbergia sissoo* (Shisham)	North Zone
2.	*Ficus spp.*	North, West & South Zone
3.	*Cassia fistula (Amaltas)*	All Zones
4.	*Peltophorum pterocarpum* (Pila gulmohar)	North, West & South Zone
5.	*Terminalia arjuna (Arjun)*	North, Central Zone
6.	*Albizzia lebbeck (Siras)*	North, South Zone
7.	*Syzygium cumini (Jamun)*	North Zone
9.	*Delonix regia (Gulmohar)*	West, South & Central Zone
10.	*Phoenix sylvestris(Khajur)*	Central, South Zone

Note:

1. *North Zone includes Uttar Pradesh, Uttarakhand, Delhi & Haryana*
2. *Central Zone includes Maharashtra*
3. *West Zone includes Gujarat*
4. *South Zone includes Andhra Pradesh, Karnataka & Tamil Nadu*

ANNEXURE- 4

Agencies /Service providers for Tree Translocation/Transplantation

GOVERNMENT AGENCIES

Sl. No.	Name of Agency	Turnover	Experience
1.	Uttar Pradesh Forest Corporation, Aranya Vikas Bhawan 21/475, Sector 21, Indira Nagar Lucknow-226016 UTTAR PRADESH	-	6 years
2.	AP Greening and Beautification Corporation, Vijaywada-520003 ANDHRA PRADESH	-	5 years
3.	Lucknow Metro Rail Coporation, Near Dr. Bhimrao Ambedkar Samajik Praivartan Sthal, Vipin Khand, Gomti Nagar, Lucknow-226010 UTTAR PRADESH	-	-

PRIVATE AGENCIES

S.No.	Name of Agency	Annual Turnover			Experience
		Below 50 Lakhs	50 Lakhs - 1 Cr.	Above 1 Cr.	
1.	Jayam Tree Translocation, No 20, 2nd street seevaram OMR Road, Chennai TAMIL NADU	Rs. 20 Lakhs	-	-	18 Years
2.	Lovely Gardener, Borabazaar fort Mumbai-400001 MAHARASHTRA	10 Lakhs (Approx)	-	-	-
3.	TMRH Plantation, Basavanagudi, Bangalore-560004 KARNATAKA	4 Lakhs (Approx)	-	-	18 Years
4.	Aksha Development Research and Consulting Pvt. Ltd., Salt Lake City, Kolkata-700064 WEST BENGAL	36.79 Lakh	-	-	4 Years
5.	Vinca Horticulture & Landscape Pvt. Ltd., Jamia Nagar Okhla, NEW DELHI-110025	-	Rs. 80 Lakhs	-	2 Years

S.No.	Name of Agency	Annual Turnover			Experience
		Below 50 Lakhs	50 Lakhs - 1 Cr.	Above 1 Cr.	
6.	Rahul Mahajan Durga Dass Hybrid Seeds (P) Ltd, Sector-27d, CHANDIGARH	-	75 Lakhs	-	5 Years
7.	* Mayur Trading Company, Spine Road, Bhosari Pune-411039 MAHARASHTRA	-	-	4.27 Cr.	4 Years
8.	*VE Commercial Vehicles Ltd. Volvo Trucks Division, Bangalore-560093 KARNATAKA	-	-	11.00 Cr.	3 years
9.	*Rohit Nursery, Palam, NEW DELHI-110045	-	-	1.05 Cr.	13 years
10.	*7 Petals Horticulture (India) Pvt. Ltd., Vikhroli (East), Mumbai-400083 MAHARASHTRA	-	-	2.94 Cr.	6 years
11.	*Green Morning Horticulture Pvt. Ltd, Plot No 634, OU Colony, Shiekpet, Hyderabad ANDHRA PRADESH	-	-	1.82 Cr.	10 years
12.	*PGB Intelligent Force Pvt. Ltd., Dwarikapuri, Chutiya, Ranchi, JHARKHAND	-	-	3.22Cr.	2 years

**Heavy machineries and cost is involved in tree translocation, 6 agencies dealing with tree translocation are reported to have more than 1 crore annual turnover in India.*

ANNEXURE – 5

The Machines available in market to help the Translocation/ Transportation of Trees

1. Tree Spade Trucks

- **Transplantation of small sized trees**

Tree spade is a simpler way of transplanting trees but it requires specialized equipment's and its application is limited to smaller to medium sized trees. Since the ball of earth from tree spades are more narrow and deeper than conventional hand dug balls selection of smaller girth size (less than 60cm) trees will be more appropriate for this method. Further it's application s limited for a short distance transplantation.

Tree Spade

Figure above- Tree spade mounted on excavator and Skid Steer Loader

[Content Source - https://macbert.net/best-tree-spade/]

To pick the proper and best tree spade attachment for the application, it is important that operators should know what kind of blades to use of on a tree spade, what size of machine is required, and what are the necessary configurations to set-up for the loader.

Kinds of tree spade's blades

There are mainly three varieties of tree spade blades configurations: cone, truncated and half moon. The type of tree spade blade to be used will depend on what the contractor is attempting to achieve and the kind of soil in which the spade would operate.

Cone blades

The cone blade can function in the widest variety of soils – sandy to hard-packed soils –it is preferred in sandy soils because it minimizes the amount of soil that spills away in the roots. It produces almost pointed and narrow bottom root balls with the sides of 30 degrees. Cone blade's root balls cannot remain standing as balls made by other blades.

Truncated blades

Truncated blades dig most effective in clay-type, heavy soils. They are the widest blades so they'll make it hard when penetreting the ground. These blades also make the root ball with a compact shape in weight distribution. Truncated blades lop off the bottom in the cone-shaped hole that the spade digs to create a pot-shaped root-ball and make it fit for a pot or burlap bag to be displayed and stored in a vertical position. These blades are of 22 degrees. Truncated blade is a very good choice when working in tight tree-rows on a nursery, simply because it can get to where it requires working without doing damage nearby trees within the row.

Half moon blades

The half moon blades can be used only through vibrations and they'll produce an half sphere clod that will need a special pot to maintain a vertical position. It retains a big soil's amount in the clod, leaving the root system alone, if accordingly, big due to the vibrations.

Chassis Mounted - Fully Contained – One Operator System - Tree Transplanting Machine: FMX 460 8X4 TREE TRANSPLANTER by Volvo Trucks, India.

(https://www.volvotrucks.in/en-in/trucks/special-application/tree-transplanter.html)

- **Transplantation of medium to large sized trees:**

For trees of medium to large girth size starting from preparation of ball of earth to planting in receptor site heavy machines and vehicles like excavators, back hoe, cranes and trailer truck etc., are needed.

TREE TRANSPLANTER FIXED ON EXCAVATOR

(Picture Source - https://www.alibaba.com/product-detail/tree-transplanter-machine-fixed-on-excavator_60599683232.html)

TREE TRANSPLANTER

(Picture Source - https://www.alibaba.com/product-detail/tree-transplanter-machine-fixed-on-excavator_60599683232.html)

A. LIFTING **B. MOUNTING**

[HEAVY MACHINES/CRANE USED FOR BIG SIZE TREES]

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