



**MINISTRY OF FORESTRY
FOREST DEPARTMENT
AND**



**INTERNATIONAL TROPICAL TIMBER ORGANIZATION
(ITTO)**

***“ Ex-Situ and In-Situ Conservation of Teak (*Tectona grandis* linn.F)
to Support Sustainable Forest Management ”***
ITTO Project PD 270/04 Rev.2 (F)

**REPORT OF NATIONAL CONSULTANT
(TREE IMPROVEMENT)**



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1. General Description of the Project Area

The project covers relevant and suitable parts and portions of the natural teak habitats in the Sagaing, Mandalay, Bago (east and west), Magway, Yangon and Ayeyawady divisions. These six divisions are home of some of the best Myanmar teak the genetic identity and variation of which still remain unexplored, and for which it has become urgent to initiate appropriate strategies for the conservation and sustainable use of the teak genetic resources. Moreover, the six divisions also accommodate plantation centres of the special teak plantation programme which was introduced in 1998 and is in need of a timely teak improvement scheme to promote the supply of high quality teak seed and other planting materials for the operations of the plantation centres.

The area can roughly be categorized into two broad types. The areas in the close proximity of the fringe around the central dry zone have dryer climate, whereas, the remaining areas, further outward in all directions from the dry zone are moister by nature. The two main teak bearing forest types mostly found, among other types, in the project area are the Dry Upper Mixed Deciduous (DUMD) and Moist Upper Mixed Deciduous (MUMD) types. There usually is no distinctive dividing line between the two types as they are always intermingling in the ever dynamic transitional zones. It is well known, with some proof from extensive investigations, that teak from the dryer districts of the area produces wood of such quality that favorably influences preference of buyers and induces high market value, while districts having moist climate naturally accommodate teak of remarkably good growth and dimensions. The project area is ideal for the establishment of teak plantations for both quantitative and qualitative productions in its respectively suitable parts.

2. The Project

The forestry sector in Myanmar has contributed significantly to the country's total export earning and teak, particularly from the natural forests, has been a major source of foreign exchange earnings for many years. After more than a century and a half of scientific and systematic management, the natural teak bearing forests of Myanmar are still in good extent and condition compared to neighboring countries. However, due to demographic pressure and accompanying human interventions through shifting cultivation, illicit logging, agricultural expansion, general encroachment and excessive firewood cutting, forest degradation, with possible genetic wearing, has been experienced with decreasing production. Myanmar now encounters the challenging task to restore its degraded forests, preserve its genetic resources especially of teak, and enhance the existing natural stock of teak not only by assisted natural means, but also artificial innovations.

The Myanmar Forest policy, 1995 stipulates that the natural forests of Myanmar will not be substituted by plantations. However, in addition to cultural treatments provided to conserve the genetic resources and assist natural regeneration to a healthy maturity, tree planting of small and moderate scales are afforded to enrich the natural stands, while larger plantations are established to reclaim the depleted teak bearing areas and build up new wood capitals. The natural forests, including 16.5 million ha of teak bearing types, will continue to provide timber, especially premier teak wood, sustainably while rendering protective functions to ensure genetic conservation, ecological stability and biodiversity integrity with supportive services for agriculture, recreation and ecotourism. Due to the greater demand in timber, a greater share of the

economic burden in forestry will inevitably be shifted gradually to plantations. With the application of time-proven techniques and quest for newer still innovations, large scale plantations are, therefore, being established complementary to the main effort in natural forest management.

The following table shows teak plantation areas planted up annually up to 2007 in comparison with plantations of other species.

Table 1. *Plantations established by Year and Species (1896-2007)*

(acres)

Year	Species					Total
	Teak	Pyinkado	Padauk	Pine	Others	
1	2	3	4	5	6	7
1896-1941	91256	3160	126	-	22010	116552
1948-1962	3039	-	-	-	1710	4749
1963	334	714	-	49	734	1831
1964	793	657	-	180	2405	4035
1965	1910	2122	-	126	2553	6711
1966	1819	1376	-	116	2750	6061
1967	2720	1369	2229	-	2276	8594
1968	3976	2191	-	1413	1775	9355
1969	2936	1530	-	1102	1546	7114
1970	3282	1601	-	30	3017	7930
1971	2523	1488	-	89	2750	6850
1972	1841	791	-	-	5152	7784
1973	2192	1530	-	-	3007	6729
1974	2123	153	-	-	4065	6341
1975	2256	660	-	-	4680	7596
1976	2530	1201	-	-	3991	7722
1977	3546	1510	-	-	3892	8948
1978	4410	1152	-	-	5073	10635
1979	6405	1423	99	-	8706	16633
1980	15323	2978	899	499	13648	33347
1981	21481	4413	1159	1043	14522	42618
1982	25966	5844	1908	1316	19910	54944
1983	29223	5434	3052	800	29719	68228
1984	29156	9328	2392	1903	33369	76148
1985	26784	13833	2311	2950	43923	89801
1986	27120	13425	1900	2550	36416	81411
1987	28551	6054	2901	2901	39428	79835
1988	28515	5435	2850	550	36570	73920
1989	25047	1845	2000	1150	16237	46279
1990	36436	4964	3150	700	30605	75855
1991	36367	4096	3544	1000	31681	76688
1992	34354	5251	1710	1500	35235	78050

Year	Species					Total
	Teak	Pyinkado	Padauk	Pine	Others	
1	2	3	4	5	6	7
1993	26615	3200	1797	1500	43515	76627
1994	11030	2785	525	1250	40210	55800
1995	24765	1904	1310	1155	50183	79317
1996	25808	2465	1795	3065	47824	80957
1997	27506	2590	1330	2850	40310	74586
1998	36304	1998	1210	1950	29580	71042
1999	35233	3597	570	3260	33236	75896
2000	31905	5610	950	3155	34286	75906
2001	31972	3133	250	3010	37635	76000
2002	32150	2750	300	2600	39780	77580
2003	32075	3190	250	2400	37305	75220
2004	33990	3485	150	2600	38785	79010
2005	37077	3490	100	1550	39825	82042
2006	29215	2625	50	350	37760	70000
2007	28925	1800	225	900	27210	59060
Total	948784	152150	43042	53562	1040799	2238337
%	42.4	6.8	1.9	2.4	46.5	100

In addition to the aforementioned teak plantations a special teak plantation programme was initiated in 1998. The programme with a rotation of 40 years was formulated with 8 consecutive phase, each accommodating 20 plantation centres with a duration of 5 years. With each centre having an annual planting rate of 1000 acres (405 ha), a total of 100,000 acres (40,500 ha) are being planted up at the 20 centres for each 5 year phase leading to a grand total of 800,000 acres (324,000 ha) by the end of the 40 year rotation, after which 20,000 acres (810 ha) will be available annually for harvesting from the 20 centres. The plantation centres are located in the natural teak habitats of Sagaing, Mandalay, Bago, Magway, Yangon and Ayeyarwady divisions, all of which accommodate activities of the ITTO project. The programme is peculiar in having characteristics like the use of superior genetic resources, better care in site selection and preparation, timely application of tending operations and due attention to protective efforts against pest, diseases, wildfires, etc. Apart from quantitative production, qualitative improvement is also being afforded.



Special Teak Plantation, 2005

All teak plantations of Myanmar have now been brought up to the standard of the special teak programme erasing the difference between the special and normal teak plantations and the necessity to refer to them separately. Since genetic heredity and the environment have great influence on the growth and quality of teak, only teak of Myanmar origin are used for planting in the natural habitats that have carried and produced teak wood of premier quality since time immemorial. Other improvements include the use of improved planting materials to replace traditional seed sowing and stump methods, selection of SPAs with dual purposes for *in-situ* gene conservation and quality seed supply, establishment of CSOs for long-term teak improvement objectives, application of micro and macro vegetative propagation methods for cloning to facilitate tree improvement efforts through the establishment of CSOs and hedge gardens and propagation of vegetative plantlets for the appropriate outplanting purposes. All these demand technology, some of which are acquired, but others still sought for.

The ITTO project, as its name implies, is being implemented with the aim to promote and strengthen *in-situ* and *ex-situ* conservation of teak genetic resources followed by the sustainable use of the resources through an effective teak improvement effort. It is expected that the project will yield invaluable results and long sought-for technologies that will contribute very appreciably to sustainable forest management in Myanmar.

3. Project Objectives

3-1 Development Objective

The overall objective of this project is to promote the production of high quality teak through its genetic improvement in order to support sustainable forest management in Myanmar.

This, in turn, is to enhance the economy of the country through sustainable production and export of high quality teak by using good quality seed for planting. The project will be in support of increased timber production, particularly teak, so that international trade of high quality tropical timber would be sustained and enhanced for the benefit of both producer and consumer member countries of ITTO.

3-2 Specific Objectives

Specific objective 1 : To establish Seed Production Areas (SPAs) and initiate activities for the establishment of Seed Orchards for production of high quality seed.

Specific objective 2 : To strengthen the tissue culture laboratory and produce high quality plantlets through tissue culture and shoot cutting from hedge garden.

4. Programmes and Operational Activities

4-1 Site selection and establishment of SPAs

Altogether six sites of SPAs, each with an area of 25 acres (10ha), have already been selected in the Pyinmana, Natalin, Paukkaung, Saw, Kanbalu and Myanaung townships. The establishment of the SPAs in the former three townships was sub-contracted to Forest Resource Environment Development and Conservation Association (FREDA), an NGO based in Yangon, and had already been completed. The establishment of those in

the latter three townships has already been sub-contracted to the Technology, Environment and Development Cooperation (ECODEV), another NGO also based in Yangon, and as in the former three SPAs, the establishment will be executed in accordance with the instructions and close guidance of the NPM, Consultants and staff of the project.



SPA,34 years old, Pakkhaung



SPA 17 years old, Nattalin
(just after thinning)

Since the main purpose of the SPAs is to supply high quality teak seed, only trees of superior phenotypic traits are retained as seed trees and inferior ones removed in thinning operations which are heavier than those done for normal plantations. The thinning intensity is no lighter than grade E thinning. The following table shows the selected SPAs together with the number of seed trees retained and the inferior trees removed, or to be removed, in the respective thinning operations. More detailed information on the SPAs is attached in Annex I.

Table 2. SPA established by Project

No.	Location	Year established (age)	Original area (ac)	Area selected for SPA	Total number of trees	Number of trees retained	Number of trees removed
1.	Compt. 59, Taung Nyo Reserve, Pyin mana Tsp.	1966 (41 yrs)	40	4.05 ha (10 Ac)	350	262	88
	Compt. 78, Nglai Reserve, Pyinmana Tsp.	1984 (23 yrs)	120	6.07 ha (15 Ac)	624	351	273
2.	Compt. 49, South Nawin Reserve, Paukkaung Tsp., West Bago Div.,	1973 (34 yrs)	50	10.12ha (25 Ac)	1002	658	344
3.	Compt. 99, Bawbin Reserve, Nattalin Tsp., West Bago Div.,	1991 (17 yrs)	120	10.12ha (25 Ac)	3726	1740	1986
4.	Compt. 74, Saw(1) Reserve, Saw Tsp. Magawe Div.	1983-84 (24 yrs)	40	12.12ha (25 Ac)	2781	1335	1446
5.	Compt. 192, Thaw Reserve, Kanbalu Tsp., Sagaing Div.,	1967-68 (40 yrs)	50	10.12ha (25 Ac)	1716	764	953
6.	Compt. 44,46, Myinwataung Reserve, Myanmaung Tsp., Ayeerwaddy Div.,	1981 (27 yrs)	130	10.12ha (25 Ac)	1245	648	597

4-2 Selection of Plus Trees and collection of clones and seeds



Plus Tree selection in South Zermayi Reserve, Bago (East)



Plus Tree selection in Thaw Reserve, Kanbalu

Identification and selection of plus trees, together with clone collection, has been carried out since the beginning of the project. Plus trees have been selected from different locations and explants were collected from some plus trees for vegetative propagation. Seeds were also collected to conduct sexual reproduction for the various experiments. The plus trees selected are located in Pyay, Paukkaung, Pynmana, Kanbalu, Bago and Oaktwin townships. Most of the plus trees selected to date are in the eastern and western aspects of the Bago Yoma which is known to host the qualitatively best teak of Myanmar. Many of the plus trees selected are of plantation origin due to accessibility, and also the fact that plantations which receive proper treatments have more trees of phenotypic superiority. However, some plus trees have also been selected in the natural forests of Bago, Pynmana, Leway and Oaktwin townships and more naturally growing plus trees will be added to the collection. Plus tree selection is based on phenotypic characteristics and in accordance with the instructions formulated by the project. The list of plus trees selected to date is attached in Annex II.



Plus Tree in Natural Forest, Bago



Plus Tree Identification

4-3 Establishment of provenance trials

Two teak provenance trials have been established. One is located in compartment 18, Ngalaik Reserve in Pyinmana Township, and the other, in Compartment 91, Yenwe Reserve in Kyauktaga Township. In both trials the provenances are deployed in Randomized Complete Blocks (RCB) design with the application of 5 replicating blocks. The former trial is composed of 8 provenances in an area of 2.82 acres (1.14 ha) and the latter comprises 9 provenances covering 3.17 acres (1.28 ha) . The trees are placed at 9' x 9' spacing in plots of 25 trees of the same provenance. There are buffer lines between plots, on which *Leucaena leucocephala* is planted, also at 9' interval, without disrupting the alignment and spatial design of the trials. Layout and other details of the provenance trials are attached in Annex III.



Provenance Trial, Kyauktaga



Provenance Trial, Pyinmana

4.4 Establishment of hedge gardens and Clonal Seed Orchards (CSO)

A hedge garden comprising 131 grafted plantlets and representing 22 clones was established within the FRI compound at Yezin. More clones will be added to enrich the clone bank which will be further utilized for vegetative propagation.



Hedge Garden at FRI



Clonal Seed Orchard, Pinyinmana

To facilitate large scale planting through the supply of sexually reproduced quality seeds, two CSOs have been established with vegetatively propagated plantlets from the selected plus trees. One CSO, established in compartment 18, Ngalaik Reserve, Pyinmana Township, is composed of 123 ramets representing 26 clones. The other, located in compartment 17 of Tone ye Reserve, Pyay Township has been established with 25 clones represented by 191 ramets. The plantlets, at 36' x 36' spacing, are randomly placed with some adjustment to prevent ramets of the same clone being adjacent to avoid inbreeding. The CSOs are isolated from other teak bearing areas to prevent pollen contamination from the exterior. Layout and details of the CSOs are attached in Annex IV.

4.5 Renovation of existing infrastructures

Apart from the aforementioned accomplishments the project has renovated some existing infrastructures in an attempt to revitalize their functions which are of paramount importance for tree improvement.

4.5.1 Tissue culture laboratory

Tissue culture, though by itself alone is not a tree improvement process, is an essential part of it through the cloning of superior genotypes. It is a handy tool for the establishment of clone banks and CSOs which are crucial for a tree improvement programme.

The teak tissue culture laboratory of the Central Forestry Development Training Centre (CFDTC) at Hmawbi, Yangon Division, in which the first successful tissue culture of teak in Myanmar had been conducted, has been renovated and strengthened by the project. The layout of the laboratory has been reorganized to be in line with the requirements of the project and in accordance with the advice and guidance of the International and National Consultants concerned. It has also been upgraded with equipment and chemicals at the expense of the project.

The nearby glasshouse has also been replenished to nurse the tissue cultured and other vegetatively reproduced plantlets. The addition of more clones from the newly selected plus trees to the hedge garden of the center is also being considered.



Tissue Culture at CFDTC



Glass House of the Center

4.5.2 Permanent nursery

The permanent nursery of FRI at Yezin, Pyinmana Township has been restructured to raise more seedlings, especially as stock to accommodate vegetative cuttings from the selected plus trees. Seeds of various provenances were also sown, and the resulting seedlings raised, here for the provenance trials. Seeds of provenances were also stored and processed at the FRI seed laboratory in which a germination test showed an average 44% success, with 60% and 25% for the best and poorest provenances respectively. A remarkable result by teak standard.

4.6 Local Community participation in SPA establishment

Local community participation and development in the establishment, maintenance and use of SPAs was initiated by the project through a sub-contract to ECODEV and close supervision of the NPM, National Consultant and project staff concerned. Added incentive is provided through the formation of Income Generation Groups (IGG) for the participating community members in all the 6 SPA sites. A revolving fund system has been established to allow micro-credit activities which are compatible with SPA objectives. Income from the other activities together with that from the sale of seed collected from the SPAs greatly improve the livelihood of the IGG members. For the Forest Department, the procurement of quality teak seed of known origin is also facilitated.

4.7 Capacity building

Training courses, study tours and seminars have been conducted or prepared to promote the capacity of project and department personnel and local communities participating in SPA activities.

4.7.1 Training and study tours

A training course for tree improvement, tissue culture techniques and hedge garden establishment was conducted in February, 2007 at CFDTTC for 20 in-service trainees from 9 States and Divisions, including the 6 divisions which accommodate project activities, and 2 research assistants from FRI.

Another course on SPA establishment and maintenance, genetics and tree improvement, seed handling , soil analysis and community development was conducted in March, 2007 at FRI for 20 Forest Department personnel and community members, comprising a team of one forestry staff and two local farmers from each of the six project SPA sites and 2 FRI staff members.

4.7.2 Overseas training

The project has undertaken procedures to dispatch 2 researchers for an overseas training on "Molecular and Biotechnological Techniques in Tree Improvement " to be conducted at KFRI, India.

4.7.3 Seminar

A seminar on SPA management and tree improvement has been organized for 30 participants from the project area and researchers of FRI. Dr Susumu Kurinobu of FTBC,

International Consultant, participated as resource person. Papers were also presented by the NPM, Consultant and staff of the project.

5. Terms of Reference for the Consultancy (Tree Improvement)

The National Consultant in Tree Improvement must be a Myanmar citizen with experience in tree improvement or plantation silviculture, hold at least a Master degree in science and proficient in English.

The main responsibilities of the National Consultant in Tree Improvement are:

- 1) to prepare instructions for identification of plus trees
- 2) to participate in the identification of plus trees
- 3) to participate in the establishment of hedge garden
- 4) to prepare reports and manuals

5.1 Fulfillment of the term of reference

5.1.1 Preparation of instructions for identification of plus trees

When the National Consultant for tree improvement was first engaged, a very comprehensive draft guideline, "Qualitative Assessment of Teak Trees as Guide for Selection of Plus Trees" had already been prepared by the NPM. The National Consultant's contribution is, therefore, concerned with the reviewing of the draft, discussion with the NPM and other consultants, addition of some points and general edition of the instructions so as to simplify and make them more user-friendly, especially for the field staff.

5.1.2 Participation in the identification of plus trees

During the 3-month consultation, the National Consultant for tree improvement accompanied the NPM, National Consultant for SPA Management / Silviculture and other project staff members on field trips and participated in the identification of plus trees using the draft instruction to test its applicability with some improvements where necessary. Opportunities were also taken during the trips to select, confirm the selection and take measurements of seed trees in SPAs with some field inventory to facilitate thinning.

In addition to the plus trees already selected by the project, more had been selected, measured and recorded in compartment 51 of South Nawin Reserve, Paukkaung Township, Bago (west) Division, compartment 56 of South Zamayi Reserve, Bago Township, compartment III of Kabaung Reserve and Protected Public Forests of Oktwin township, Bago (east) Division and compartment 192 of Thaw Reserve, Kanbalu Township, Sagaing Division during the trips.

SPAs tentatively selected in compartment 49 of South Nawin Reserve, compartment 192 of Thaw Reserve and Compartment 74 of Saw (1) Reserve, Saw Township, Magway Division had also been rechecked and confirmed after detailed measurement. An old plantation comprising teak trees which seemingly have better maturity and phenotypic appearance in Saw Township was reluctantly left out as it could not meet the criterion of area dimension specified in the instructions.

5.1.3 Participation in the establishment of hedge garden

The hedge garden comprising 131 grafted plantlets of 22 clones accumulated to date was visited at FRI, Yezin. Since the plantlets had to be planted out only a few months after grafting the staff responsible for the maintenance of the garden had been cautioned to carefully nurse the planted stock together with the back-up and new plantlets held in reserve for possible replacement or new planting. Two Clonal Seed Orchards, one comprising 123 ramets of 26 clones in compartment 18 of Ngalaik Reserve, Pyinmana Township, and the other with 191 ramets of 25 clones in compartment 17 of Tone Ye Reserve, Pyay Township were also visited. After careful inspection, the responsible staff were given instructions on the maintenance of CSOs, including preventive measures against accidental wildfires at Ngalaik and replacement of some failed plantlets at Tone Ye.

There are 2 established provenance trials, of which the one located in compartment 18 of Ngalaik Reserve was inspected. The visit to the other trial established in compartment 91 of Ye-nwe Reserve in Kyauktada Township, Bago (East) Division was postponed to the next trip due to time constraint. The former trial accommodates 8 provenances while the latter includes 9, with both sets deployed in a randomized complete block (RCB) design with 5 replications. Apart from a negligible number of mortality in a water-logged corner of the former, all trees appeared in good health and sizes which were measured for later analysis.

5.1.4 Preparation of reports and manuals

The National consultant has been involved in the preparation and editing of some progress reports, instructions, guides and seminar papers prepared by some project staff members. The consultant also reviewed, in reports, some analysis of statistical data collected to date by the project staff with some suggestions for possible improvements, especially in record keeping and presentations.

The consultant has also studied a variety of tree improvement programmes previously suggested and recommended for Myanmar by international organizations and individual experts. The extent, limitations and feasibility of each recommended programme was discussed with other consultants and staff of the project.

In addition to the fulfillment of the term of reference for the consultancy, the consultant has assisted the NPM on the procedures in the selection and dispatch of project staff members for overseas training and study tours concerning with tree improvement.

6. Constraints and Limitations

- 1) The Project, with a 3-year duration, will meet its immediate objective to initiate *In-situ* and *Ex-situ* Conservation with the earlier steps of tree improvement works. However, more time and resources are needed to undertake a more determined long-term tree improvement programme.
- 2) One of the project activities, SPA establishment which is the first and very important step toward tree improvement, is exemplary but limited in extent. Plantation centres will have to follow the examples in the selection, maintenance and utilization of their own SPAs to meet the quality seed requirements of the plantation programmes.
- 3) SPAs, with the dual purposes for quality seed supply and *In-situ* Conservation of teak gene resources, can be selected from natural forests or plantations. For the latter purpose it is difficult to find a natural stand containing enough seed trees in sufficient spatial extent to meet the criteria set in the instructions for SPA selection. All of the SPAs selected by the project to date are in plantations.
- 4) It is recommended to select as many plus trees as possible to include the widest possible variety of superior phenotypes. Though there definitely are many such trees in the natural forest, they are so widely distributed and far apart that it takes much time and effort to find them. Conversely, such trees may be converged in large numbers in plantations, but it is also advised not to take many from each location to avoid the inclusion of trees of the same genotype leading to inbreeding. The number of phenotypically superior trees selected to date may fall far short of that in actual existence.
- 5) Trained Myanmar foresters, some as they are, and others with some more practice, can undertake tree improvement steps in the initial stages, e.g. SPA establishment, plus tree selection, provenance trials steps etc., and some researchers and trainers can operate vegetative propagations to establish hedge gardens and CSOs with which a genetic improvement programme can start and be built on. However, FD is still in need of skilled personnel, preferably geneticists, to conduct clonal tests and progeny trials of clones in a later stage to assess genetic gains in the early generation, and proceed with the next generation improvement in a long-term tree improvement programme.

7. Recommendations

- 1) It is strongly recommended to eliminate uncontrolled harvest of seeds of poor or unknown origin. Production and use of seeds from well managed SPAs is the first, simple and very important step toward tree improvement and sustainable use of genetic resources.
- 2) Conservation of genetic sources of Myanmar teak, with large genetic variation, is important for future generations. It is also the basis for tree improvement, so *in-situ* conservation, not only in selected plantations but also in natural forests, should be afforded as much as possible.
- 3) The dual purposes of SPAs are for quality seed production and *in-situ* conservation. Since it is difficult to find natural stands which can meet the criteria laid down in the instructions for SPA selection, it may be helpful to have special consideration for natural forests with some exceptions to the rules. Alternatively, for exceptionally good stands, it may be rewarding to consider the separate establishment of *in-situ* teak preservation plots. Compartment 56 of South Zamayi Reserve is a good example.

- 4) For the exclusive purpose of quality seed production, plantation will play a dominant role in providing seed stands which will be the back bone of tree improvement in the immediate future.
- 5) SPAs established by the project are models of limited extent and territorial units (districts and townships) are strongly encouraged to establish their own SPAs, or see that already established SPAs are brought up, to the standard that can sufficiently provide for their plantation requirements. It is also recommended that the instruction for the establishment of SPAs drafted by the project is authorized for use not only for the establishment, but also management and effective use of the SPAs
- 6) Plus trees can be selected from the natural forests, plantations or SPAs, preferably to the standards of the "Guide for selection of plus trees" formulated by the project. They are the main source to form a basis for an efficient short or long term tree improvement programme.
- 7) As in the case of SPAs, it is easier to find more plus trees in plantations as they not only have a larger concentration of trees per unit area but also a greater proportion of phenotypically superior types due to the thinning operations in which inferior trees are removed. However, plantations, especially old ones, usually contain trees from seeds of the same or few mother trees and have little genetic variation. It is suggested not to select many plus trees from one location to avoid the accumulation of plus trees of identical clones.
- 8) It is recommended that plus trees of outstanding phenotypes in the natural forests are selected wherever possible and propagated in clone banks, hedge gardens or CSOs.
- 9) Existing FD personnel, including researchers and trainers, can effectively undertake the establishment of SPAs and following tree improvement steps e.g. plus tree selection, provenance trials, establishment of hedge gardens and CSOs, etc. However, FD is still in need of skilled geneticists or scientists who can first conduct clone tests to find the best genotypes from the selected plus trees and, later, for the newly established CSOs when they start to produce seeds, in order to assess the genetic gains and, by roging the CSOs, start a new generation of tree improvement process. It is suggested that promising forestry scientists are given the privilege to acquire knowledge and skill in genetics through overseas training.
- 10) Such skilled personnel can also immediately conduct clonal tests in the old CSOs established in the early 1980s and confirm, or otherwise, once and for all the genuineness of the clones of plus trees selected in the past. This could assist or, given favourable results from the tests, even hasten the tree improvement process by revitalizing the old CSOs.
- 11) Tree improvement programmes have been prepared and recommended for Myanmar by three different international organizations and individual experts in the past; the last one being the proposal of the International expert of the ITTO project. If it is desired to implement a systematic long-term tree breeding and improvement programme, it would be appropriate to conduct a study on the feasibility, cost-effectiveness and possible dimension of a suitable programme in conjunction with matching financial assistance that would possibly be available for the programme.
- 12) The present project will definitely fulfill its objectives and obligations at its termination. In order to be able to implement a determined long-term tree improvement programme, it is recommended that proposal for a tree improvement project is prepared either in the form of the continuation or

extension of the present project or as a new project with the same external source of financial assistance. Alternatively, it may also be in the form of a new proposal to the interested external governmental agency with whom discussion on bilateral cooperation in the related field has been established, but is still pending.

- 13) In the absence of the aforementioned new project, it is recommended that Forest Department, particularly, present staff members of the project, continue to endeavour on the tree improvement effort in accordance with the findings and instructions prepared by the project, the application of which would definitely guarantee a certain degree of success in tree improvement and sustainable use of the teak genetic resources.

SPA established in 1st year

No.	Location	Established Year (age)	Original Area	Area selected for SPA	No. of trees (Before Thinning)	No. of trees (After Thinning)	No. of trees (Thinned trees)
1.	Compt. 59, Taung Nyo Reserve, Pyinmana Tsp. Nay Pyi Taw Div.,	1966 (41) Years	40	40.5 ha 10 Ac	350	262	88
	Compt. 78, Taung Nyo Reserve, Pyinmana Tsp. Nay Pyi Taw Div.,	1984 (23) Years	120	6.07 ha 15 ac	624	351	273
2.	Compt. 49, South Nawin Reserve, Paukkaung Tsp., West Bago Div.,	1973 (34) Years	50	10.12 ha 25 Ac	1002	658	344
3.	Compt. 99, Bawbin Reserved Forest, Nattalin Tsp., West Bago Div.,	1991 (17)Years	120	10.12 ha 25 Ac	3726	1740	1986

SPA established in 2nd year

No.	Location	Established Year (age)	Original Area	Area selected for SPA	No. trees/ ha (Before Thinning)	No. trees (After Thinning)	No. trees (Thinned trees)
1.	Compt. 74, Saw (1) Reserved, Saw Tsp. Magawe Div.,	1983-84 (24 years)	40	10.12 ha (25 Ac)	2781	1335	1446
2.	Compt. 192, Thaw Reserve, Kanbalu Tsp., Sagaing Div.	1967-68 (40 years)	50	10.12 ha (25 Ac)	1716	764	953
3.	Compt. 44,46, Myinwataung Reserve, Myanaung Tsp., Ayeyarwaddy Div.,	1981 (27 years)	130	10.12 ha (25 Ac)	1245	648	597

Selected Plus Trees from Natural Forests

No.	Location				Code no.	dbh (cm)	Total Ht. (m)	Remarks
	Compt.	Reserve	Township	State & Div.				
1	56	S. Zarmayi	Bago	East Bago		60	35	
2						56	36	
3						53	33	
4						49	30	
5						48	31	
6						60	35	
7						49	29	
8						49	35	
9	XVII	Kabaung	Oaktwin			54	32	Protected Public Forest
10	XVII	Kabaung	Oaktwin			53	29	
11		Yanpe	Leway	Mandalay	2.1			A no. 3
12		Yanpe	Leway		2.2			A no. 1
13		Yanpe	Leway		2.3			A no. 2
14		Minpyin	Leway		1.1			AC no. 10
15		Owepauk	Taungtwingyi	Magwe	8.1			AD no. 1
16		Owepauk	Taungtwingyi		8.2			AD no. 2
17		Owepauk	Taungtwingyi		8.3			AD no. 3
18		Owepauk	Taungtwingyi		8.4			AD no. 4
19		Owepauk	Taungtwingyi		8.5			AD no. 5
20	195	Kabaung	Taungoo	East Bago	6.1	55	34	no. 11
21	195	Kabaung	Taungoo		6.2	43	32	no. 13
22	195	Kabaung	Taungoo		6.3	55	37	no. 1
23	195	Kabaung	Taungoo		6.4	44	36	no. 3
24	189	Kabaung	Taungoo		6.5	51	34	no. 18
25	195	Kabaung	Taungoo		6.6	57	34	no. 5
26	195	Kabaung	Taungoo		6.7	61	33	no. 6
27	195	Kabaung	Taungoo		6.8	53	33	no. 10
28	17	Ngaleik	Pyinmana		5.1	55	28	no. 21
29	81	Saiya	Taungoo		7.1	54	34	no. 27

Selected Plus Trees from Planted Forests

No.	Location				Code no.	dbh (cm)	Total Ht. (m)	Remarks
	Compt.	Reserve	Township	State & Div.				
1		Pyi Kyun	Pyay	West Bago	4.5	35	30	
2					4.3	34	28	
3					4.4	33	39	
4					4.11	26	22	
5					4.8	34	26	
6					4.2	26	23	
7					4.10	34	24	
8					4.1	38	25	
9					4.9	35	26	
10					4.7	35	33	
11					4.13	35	22	
12					4.14	38	25	
13					4.12	32	24	
14					4.6	32	25	
15	20	S. Nawin	Paukkhaung	West Bago	3.5	20	37	
16					3.10	17	35	
17					3.8	17	32	
18					3.11	14	24	
19					3.1	14	27	
20					3.7	14	24	
21					3.3	13	25	
22					3.6	15	23	
23					3.4	16	29	
24					3.9	16	24	
25					3.2	12	24	
26					3.12	13	25	
27					3.13	13	29	

No.	Location				Code no.	dbh (cm)	Total Ht. (m)	Remarks
	Compt.	Reserve	Township	State & Div.				
28	∥	∥	∥	∥	3.14	16	33	
29	∥	∥	∥	∥	3.15	17	31	
30	∥	∥	∥	∥	3.16	20	34	
31	51	S. Nawin	Paukkaung	West Bago	10.1	36	38	
32	∥	∥	∥	∥	10.2	34	28	
33	∥	∥	∥	∥	10.3	39	32	
34	∥	∥	∥	∥	10.4	35	28	
35	∥	∥	∥	∥	10.5	38	28	
36	∥	∥	∥	∥	10.6	30	28	
37	∥	∥	∥	∥	10.7	34	26	
38	192	Thaw	Kanbalu	Sagaing	9.1	44	32	
39	∥	∥	∥	∥	9.2	30	28	
40	∥	∥	∥	∥	9.3	48	35	
41	∥	∥	∥	∥	9.4	48	36	
42	∥	∥	∥	∥	9.5	53	34	

**Layout and Design for Teak Provenance Trial
Pyinmana Township, Ngalaik Reserve Forest, Compartment 18**



17	18	14	16	15	11	13	12
22	21	23	28	27	24	25	26
36	35	37	34	33	32	38	31
48	43	41	42	46	47	44	45
54	57	56	55	51	58	52	53

Note.

1 st Digit -	Block No. (Replication)
2 nd Digit-	Provenance No.
No. of Provenances	8
	1. Nattalin
	2. Paukkhaung
	3. Kanbalu
	4. Oaktwin
	5. Taungoo
	6. Phyu
	7. Bago
	8. Thabeikkyin
No. of Blocks (Replication)	5
No. of trees per plot	25 (5 rows and 5 columns)
Spacing	9 ft x 9 ft
Area	2.82 ac (1.143 ha)
Experimental Design-	RCBD (Randomized Completely Block Design)

**Layout and Design for Teak Provenance Trial
Kyauktaga Township, Ye New Reserved Forest, Compartment 91**



14	16	12	13	15	18	19	17	11	
23	21	24	29	27		26	25	22	28
35		38	37	32	33	34	31	36	39
		47		44	41	45	42		
			49	48	46	43			

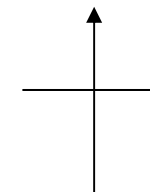
	57	53
	9	54
52	55	51
	58	56

Note:

1 st Digit -	Block No. (Replication)
2 nd Digit-	Provenance No.
No. of Provenances	9
	9. Nattalin
	10. Paukkhaung
	11. Kanbalu
	12. Oaktwin
	13. Taungoo
	14. Phyu
	15. Bago
	16. Thabeikkyin
	17. Kyauktaga
No. of Blocks (Replication)	5
No. of trees per plot	25 (5 rows and 5 columns)
Spacing	9 ft x 9 ft
Area	3.17 Ac (1.28 ha)
Experimental Design-	RCBD (Randomized Completely Block Design)

Annex (IV)

N



**Design for Experimental Clonal Seed Orchard,
Nay Pyi Taw, Pyinmana Township, Ngalaik Reserved Forest, Compartment 18**

		2.3	4.6	8.4					
		8.2	2.2	3.1					
	2.3	7.1	8.3	2.1					
2.1	8.4	2.2	4.4	8.2					
8.3	2.1	3.1	8.5	3.1	2.3	1.1			
2.2	3.2	8.4	2.2	4.7	8.1	3.1	7.1	8.1	3.1
3.1	4.1	6.7	4.5	3.7	2.2	4.6	2.1	4.9	2.2
8.4	8.1	2.1	3.1	8.5	3.1	8.5	3.6	1.1	8.4
4.1	2.3	3.10	8.1	2.1	4.1	2.3	8.4	2.3	
2.2	3.1	8.3	2.3	8.4	2.2	3.7	4.4	3.10	
4.3	8.4	4.7	1.1	3.1	8.2	4.1	2.1	8.2	
8.3	2.1	3.1	8.5	4.9					
2.3	3.9	8.1	2.1	8.2					
3.2	4.5	2.3	4.3	2.3					
8.4	2.1	8.5	2.1	3.6					

		8.4						3.7	8.3	2.2	8.1
2.1	4.5	2.3	4.6	2.2	8.3	4.7	8.4	4.1	3.1	8.5	3.1
8.2	3.1	8.1	2.1	8.5	3.1	8.5	3.9	8.1	2.3	4.9	2.1
2.3	8.4	2.2	3.2	2.3	6.7	2.3	4.1	1.1	8.4	3.10	8.4
1.1	4.3	3.1	8.4	3.1	8.2	3.7	8.1	3.1	4.4	8.2	
8.4	2.2	8.2	2.3	4.7	2.2	8.3	2.3	8.3	2.1		
3.1	8.3	7.1	3.1	1.1	3.10	4.1	3.6	4.1	8.2		
2.1	3.2	2.2	8.5	2.1	8.4	2.1	8.4	2.2	3.10		
4.9	2.3	8.4	2.1	3.1	2.3	8.1	4.5	8.5	4.6		

Note:

Area = 5.7Ac = 2.3 ha
 Spacing = 36 ft x 36 ft
 Nos.of Provenance = 7
 Nos.of Clones = 25
 Nos.of ramets = 191
 1st Digit = Provenance
 2nd Digit = Clone number

Location	Code	Remark
Leway, Minpyin	1	
Leway, Yanpae	2	
Paukkhaung	3	
Pyay	4	
Pyinmana	5	Not available
Taungoo, khabaung	6	
Taungoo, Seinye	7	
Taungtwingyi	8	

**Design for Experimental Clonal Seed Orchard,
West Bago Division, Pyay Township, Tonye Reserved Forest, Compartment 17**

8.4	2.1	8.5						
4.12	1.1	3.1						
2.3	8.2	4.12	8.3					
1.1	3.1	6.7	4.11	8.4				
8.5	4.9	8.1	3.1	4.13				
4.6	3.10	1.1	2.2	8.1	2.3		2.1	
3.1	8.4	4.4	8.2	3.10	8.3		8.5	
2.3	3.9	2.1	4.9	7.1	1.1	2.2	4.7	
8.4	4.6	8.5	3.7	8.1	4.5	8.2	3.7	8.3
1.1	2.2	6.7	2.3	4.4	2.2	3.6	2.1	4.11
4.13	8.4	4.9	8.5	3.2	8.2	4.12	8.3	3.1
2.3	4.7	2.2	3.10	7.1	4.6	2.3	1.1	2.2
8.3	3.6	8.1	4.4	8.2	3.10	8.3	4.5	8.1
3.1	2.1	4.3	2.3	3.2	2.2	4.13	2.1	3.1
4.9	8.2	3.9	8.1	4.11	8.5	3.10	8.4	4.12
2.3	3.7	2.2	4.7	2.1	3.6	7.1	4.6	8.5
8.1	4.3	8.2	3.1	8.3	4.4	8.4	3.2	4.5

Note:

Area = 3.66 Ac = 1.48 ha

Spacing = 36 ft * 36 ft

Nos. of Provenance = 7

Nos. of Clones = 26

Nos. of Ramets = 123

1st Digit = Provenance2nd Digit = Clone number

Location	Code	
Minpyin, Laeway, Nay Pyi Taw	1	
Yanpae, Laeway, Nay Pyi Taw	2	
Paukhaung, West Bago	3	
Pyay, West Bago	4	
Pyinmana, Nay Pyi Taw	5	Not available
Khabaung, Taungoo, East Bago	6	
Seinyae, Taungoo, East Bago	7	
Taungtwingyi, Magwae	8	

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