

Tree Domestication

James Roshetko and Bruno Verbist



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Lecture note 6

TREE DOMESTICATION

By James Roshetko and Bruno Verbist

I. Objectives

Illustrate the importance of tree domestication for the improvement of tree productivity and reduction of deforestation.

II. Lecture

1. Background

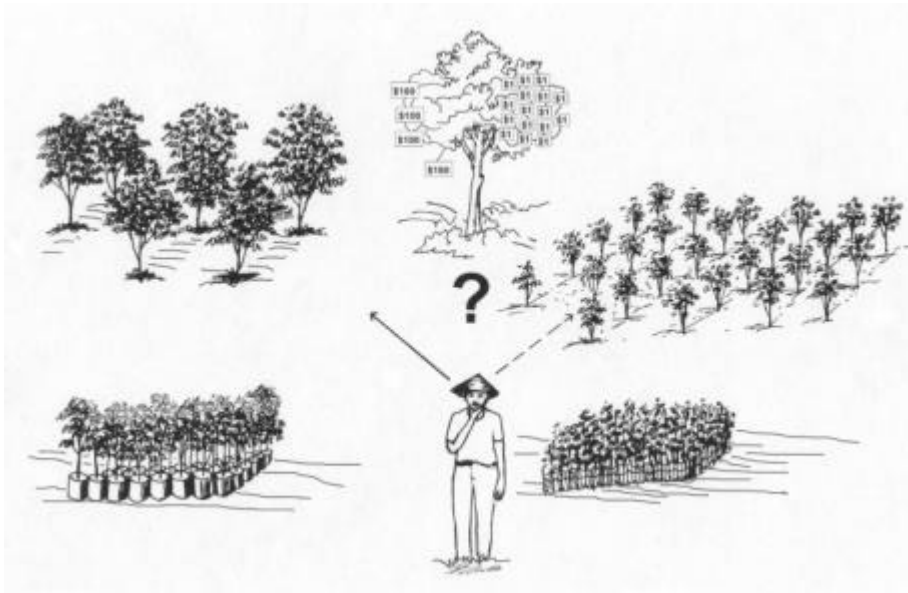


Figure1. Can tree management options for farmers be expanded?

- Why should we expand tree management options for smallholder farmers? Does it matter?
 - In developing countries the annual loss of forest is about 13.7 million hectares (CIDA, 1998), and millions hectares for Indonesia (FAO, 1997). The Philippines has no remaining undisturbed primary forests.
 - In this situation smallholders farmers across the world are planting more trees to meet household needs and market demands
 - Decreasing forest areas made the once abundant available tree resources dwindle.
 - Genetic erosion of the best tree species through loss of habitat, decreasing population and negative selection because of selective logging.

- Why do farmers plant trees?

Farmers grow trees mainly for two reasons, either for the **products** or for the **services** provided.

Products: trees are used for building construction, fuelwood, pulp for paper, resin or latex, leaves, fruits, roots, fodder, medicine etc. **Services**: trees are used as shelter, to control soil erosion, to improve soil fertility, to maintain or improve soil structure, conserve biodiversity, or sequester carbon to reduce atmospheric green house gas and thus reduce global warming.

- Can farmers be successful tree growers without any assistance?



Understanding tree domestication and good quality inputs will help farmers become successful tree growers, rather than just tree planters. Tree domestication can be characterised by four factors: **identification, production, management and adoption of desirable germplasm**. Key domestication activities include propagation, establishment, management and utilisation. Key inputs include **germplasm** and **the knowledge** necessary for farmers to make competent decisions concerning the allocation of land and financial resources regarding to tree domestication. Assistance from outside will improve the success of farmers' efforts, and reduce deforestation pressure on local forest resources.

2. What is tree domestication?

- Domestication of agroforestry trees is an *accelerated and human induced evolution to bring species into wider cultivation through a farmer-driven or market-led process* (A.J. Simons 1996). In applied terms, domestication is the naturalisation of a species to improve its cultivation and use for humankind. Basically, any activity that improves the ability of people to grow and utilise trees – either for products or services - is domestication.
- Domestication is more than just tree breeding! A common misconception is that domestication equals tree breeding - which is only one of its aspects. (As a matter of fact tree breeding is important for only a very small number of agroforestry tree species). Tree domestication includes a range of many other activities – exploration and collection of natural or anthropogenic populations, evaluation and selection of suitable species and provenances, developing propagation techniques, multiplication and dissemination of germplasm, development of management techniques, utilisation and tree-product marketing, and the development and dissemination of relevant technical information.

3. What is the tree domestication process or 'continuum'?

The process of tree domestication involves the identification, production, management and adoption of desired germplasm to meet farmer-driven or market-led needs. The domestication strategies used for individual species vary according to their functional use, biology, target environment, and the domesticator-researcher or farmer. Tree domestication can be as

“naturalisation” of a species to improve its use by human kind, where the key input to the process is **germplasm and its quality**.

The domestication process can best be described as an iterative continuum of closely related activities. Figure 3 depicts the more prominent activities in the domestication continuum.

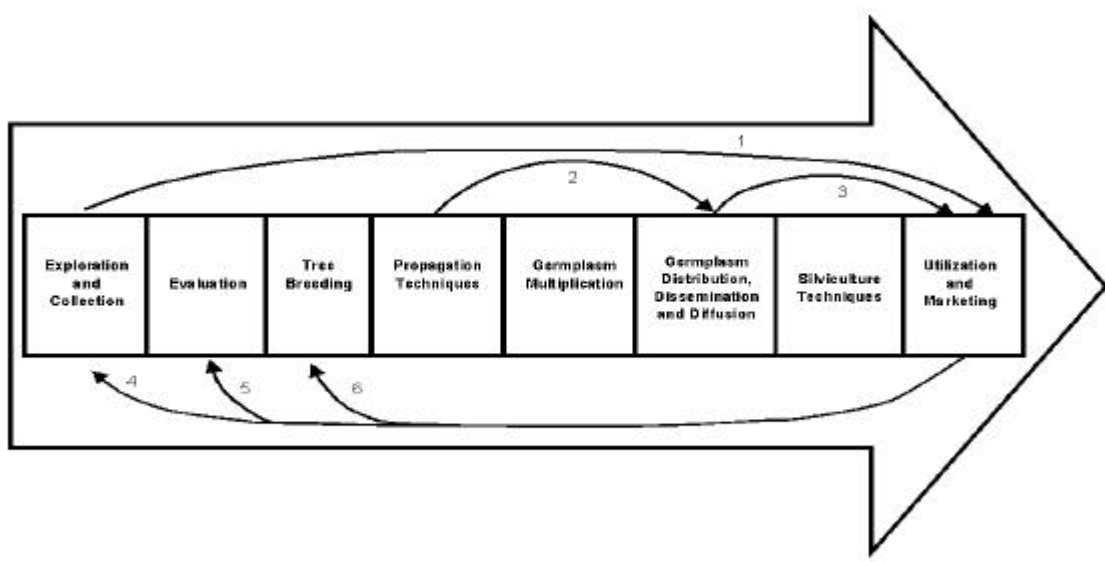


Figure 3. Tree domestication continuum. The various activities within the domestication continuum represent a general progression from the wild to genetically transformed state. However, the domestication of any given species will not necessarily follow a sequential flow from left to right. Some steps (activities) in the continuum maybe by-passed during the domestication process. Similarly, progress may flow back to earlier steps in the continuum as interest in or the economic value of a species develops further (Roshetko, 1999, p 218).

The arrangement of the various activities from left to right within figure 3 represents a general progress from the *wild* to *genetically transformed state*. The first step is usually started with exploration and collection by researchers of germplasm and farmer based information, followed by evaluation. The second step would be development of breeding methods and propagation technologies, followed by multiplication and distribution of germplasm. The third step is identification of utilised tree farming and development of silvicultural technologies, which mainly relates to tree products, and a good marketing. However domestication of any given species may not flow sequentially from left to right: Activities often occur in parallel, some steps in the continuum may be by-passed or deferred and the entire process is iterative. Information and results gained at any point along the continuum may feed back to earlier steps. Example, a ‘wild’ fruit species may be selected by farmers for home utilisation or marketing (*arrow 1*). Improved propagation methods (*arrow 2*) may increase the demand for germplasm and thus improve supply and increase marketing (*arrow 3*). Marketing opportunities may instigate renewed exploration of natural populations (*arrow 4*), re-evaluation of known genetic material (*arrow 5*), or interest in breeding (*arrow 6*). For a species with high economic value or many products, domestication activities may be almost continuous, while for less valuable or useful species activities will be less intense or may not occur at all. For some species with high economic value or many products, domestication activities may be almost continuous, while for other species, which may be considered less valuable or useful, activities will be less intense or may not occur at all. For example, *Durio zibethinus* (durian) has been domesticated by farmers and horticulturists through Southeast to select specimens with flavours preferred by local populations. *Gliricidia sepium*, a species of pantropic importance widely used in Southeast has been the target of well-financed international and regional domestication efforts to identify its best provenances for tree growth, fodder production, wood production and even seed production. *Gnetum gnemon* (melinjo), a species used in Southeast for the production of human food and fibre which have an international (regional) market, has received little domestication

attention (Suhardi, 1999). *Vitex pubescens*, a species used to reclaim *Imperata* grasslands and produce good quality charcoal, has only recently been targeted for initial domestication work (Utama et al 1999). Other species, used by rural residents, have not been domesticated at all and their botanical names are still being in dispute (for examples see Mangaoang *In Press* and Pedersen *In Press*).

Given the diverse paths the process can take, it is obvious that domestication strategies for individual species will vary according to their functional use, contemporary priority uses, biology, their target environments, and the domesticators involved – researchers, extension agents or farmers. (A.J. Simons, 1996 and 1997). Thus a single species may travel two or more domestication paths, resulting in the development of significantly different cultivars.

Example: distinct *Leucaena leucocephala* cultivars have been developed by researchers for production of small-timber and fodder. Farmers, and horticulturists, who develop fruit cultivars for different climatic conditions or taste preferences, provides another common example of different domestication pathways travelled by the same species. Development of these specific cultivars usually means a narrowing of the species gene pool. Generally one single use or function of the species is optimised.

The examples given above highlight species for which there are specific or high-value uses. Many tree species, particularly local species, are utilised for a number of products and services simultaneously, which are important but not high-value. A domestication strategy for such species may be much simpler, of low cost and contain fewer components. Domestication activities are usually opportunistic and not intensive. In such cases the gene pool remains broad.

4. Smallholders farmers can be successful tree growers

- Smallholder farmers are often unfairly identified as a main cause of tropical deforestation - without acknowledging that many farmers gain access to forest areas only after forestry companies or other industries have harvested timber or partially converted the natural forest to other uses. Furthermore, the role, and potential, of farmers as agents of reforestation is not adequately acknowledged and appreciated.
- As local forest resources disappear, smallholder farmers protect and plant more trees on farm to meet household needs and market demands for wood products. The local scarcity of forests provides farmers opportunity to diversify farm production and develop a new income stream through tree farming systems. Throughout Southeast Asia communities of smallholder farmers are initiating tree-farming schemes on land under their tenure with little assistance or encouragement from outside agencies. These farmer-initiated systems are generally successful for a number of reasons:
 - a. Smallholder farmers have **limited time and financial resources**. Each tree planted often represents a conscious investment for which another option may have been forfeited.
 - b. Farmers **restrict plantings to the number of trees that can be properly maintained**. Well acquainted with the productive potential of their smallholdings, farmers are able to select the most appropriate land available for their plantings and need not invest in expensive equipment necessary for the management of large areas.
 - c. In agroforestry systems popular among farmers, trees are often planted with or adjacent to crops. Management practices undertaken to assure good crop yields - cultivation, weed control and fertilisation – also benefit tree crops.

The combination of limited resources, small individual plantings, intimate familiarity with the planting site and farmers' self-interest result in high tree survival and good growth rates. Smallholder farmers main reason to get involved in tree farming, is a keen self-interest to

succeed and improve their families' livelihood through the production of tree products for home-use or market sale.

5. What are requirements and indicators for successful tree growers?

- Two key requirements enable farmers to be successful tree growers:
 - Secure land/tree tenure, and
 - Fair access to markets.

Secure land and tree tenure enables smallholder farmers to make the time and resource investment necessary with tree farming. Farmers know that they will benefit from their own efforts. In cases where tenure is dubious, the benefits of farmers' tree growing efforts are often seized by the local political elite or the government.

Without **access to fair access to markets**, the potential benefits of selling tree products can not be realised by farmers. It is often the case that local or national regulator agencies arbitrarily or illegally impose laws in order to extract bribes from smallholders wishing to sell tree products; or to block market access all together. If such situation exist, it is necessary to focus on rectifying the policy and enforcement environment before initiating smallholder domestication activities.

Example: Cloves were successfully planted in Sulawesi, but farmers lost interest because of reducing revenues due to government monopoly practices.

- Closely related to fair market access, is the identification of tree products for which farmers has an even or clear production advantage and for which there is a strong market. The '*commercialisation*' of the tree products will attract the attention of farmers and have a much great impact on the economic status of family than any home-use product or tree service can. Increasing family farming income is an interest to most smallholders, and a clear step towards improving the family's standard of living. ***Income will have a stronger impact on the family than any direct tree product !***

Questions:

- Do farmers in your country grow trees on their farm? Do you know what the reasons are?
- Have you ever heard of farmers losing interest in tree farming? Do you know what the reasons were?

Drawbacks of smallholder tree planting activities:

Smallholders often operate without outside assistance regarding tree-planting activities. While they are often successful, there are definite problems and shortcomings:

- Typically they have little experience with tree planting or intensive tree management
- Initial species selection, based on off-site information can prove to be inappropriate (see the Indonesian case study)
- Most new tree farmers demonstrate a lack of appreciation for germplasm quality
- Management of trees is often insufficient to ensure good growth.

Case study 1

In Indonesia, the government promoted planting of *Paraserianthes falcataria* to transmigrant farmers in North Lampung, based on a successful experience in West-Java. In West-Java fertile soils provided optimal growth and prices for the wood were high because of high demand and accessible markets. Following that experience farmers in Lampung were encouraged to plant *Paraserianthes falcataria* in great numbers, although the species often grows poorly and the local market price for its timber is low. The price was expected to rise, but no real market study was undertaken to support this assumption. Until now (1999), the price has not significantly increased. These two negative conditions will definitely hamper farmer's interest on growing trees. There is a serious risk of disenchantment and abandonment of tree planting by the smallholders involved.

Case study 2

Another example situates itself in Mindanao, the Philippines. It was found that tree farmers and local tree seed experts do not follow appropriate seed collection guidelines. They would collect seed from only a few trees without regard for the quality of the 'mother tree'. Smallholder farmers involved with timber farming are reluctant to prune or thin their timber trees because they think these activities will decrease their income. They do not realize that accelerated growth and improved tree quality in most cases will increase future profits. Material resulting from thinning and pruning operation may be sold, at low prices, to offset operational costs or can be used for home products. Additionally, thinning and pruning may make it possible to intercrop or understory farm for additional years.

As tree farming is a relatively new practice, farmers learn from mistakes, which is a long way to go and timely information can short cut this way.

Dr. Sam Koffa, working for ICRAF in the area brought smallholder treegrowers and sawmillers together in an effort to understand each other's concerns. Farmers e.g. learnt that sawmillers are much more interested in the larger diameters and give much higher prices for them, as they are confronted more and more with problems to ensure their wood supply. Many, but small, trees yield a higher biomass/ha but are not so interesting for sawmillers. Managing trees on farms would result in a higher profit for both the farmer and the sawmiller. (see fig. 1).

In conclusion, tree farming is a new activity that requires new knowledge, new information and training. The examples listed above can also be approached as opportunities from where to start smallholder-based tree farming activities.

7. What is an appropriate method for prioritising species for domestication?

Different users need different tree products and hence put their priorities differently. If one wants to stimulate tree domestication for and by smallholders, they should be involved during the process, which normally starts with a species prioritisation.

In the past, many species prioritisation exercises have been accomplished in Southeast Asia usually dominated by researchers, government agencies and bi- or multilateral projects. The processes used are largely undocumented, but appear to have been *top-down* and made in accordance with internal organisational interests. Little attempt was made to make prioritisation process participatory. Since tree domestication can be a very powerful *farmer-driven* process, farmer's needs and objectives should be paramount to the prioritisation process. Like the domestication process, species prioritisation will vary with each situation. However some general guidelines are useful.

Prioritisation is an important process because it includes:

- identification of community needs;
- evaluation of the species currently used;
- ranking of the primary uses (products and services) provided by the species;
- identification of a limited number of priority species;
- valuation and ranking of tentative priority species
- selection of priority species for domestication.

Full guidelines for this process are available in Franzel S, Jaenicke H, Janssen W, 1996.

Choosing the right trees. Setting priorities for multipurpose tree improvement. ISNAR Research Report No 8, 87 pp.

8. What are tree domestication priorities in SE Asia?

During a Regional Workshop on Domestication of Agroforestry Trees in Yogyakarta, November 1997, a strong consensus was formed among stakeholders from 13 countries in South East Asia concerning tree domestication priorities. Smallholder tree production systems, with special emphasis on timber and fruit species, were clear priorities across the region. It was confirmed that both indigenous and exotic species have important roles to play in these systems. *Germplasm production, quality and dissemination were also identified as priorities, as were both seed-based and vegetative propagation methods.* Concern was expressed over the marketing problems and policy disincentives that hamper domestication in many countries. An all-encompassing priority was additional training in relevant tree domestication topics and the dissemination of information in forms appropriate for various target audiences—researchers, field workers and farmers. These priorities echo those identified and discussed in various regional forums by the authors, researchers, extension agents, NGO's, and farmers. A summary of tree domestication priorities appropriate for Southeast Asia is:

- Expand species and provenance choice, with emphasis on timber and fruit species, including both exotic and indigenous species
- Germplasm quality and pathways to improve access to quality seed including farm-level seed production activities
- Nursery management and tree propagation techniques, both seed-based and vegetative
- Marketing problems and policy issues that hamper smallholder domestication efforts
- Training and information needs for various audiences – researchers, field workers and farmers

9. How do germplasm pathways operate in SE Asia?

In South East Asia numerous organisations and institutions and individual farmers are involved in regional tree domestication efforts, and it is impossible for any person or organisation to be fully informed. Pathways of tree domestication in SE Asia are presented in schematic form in Figure 4.

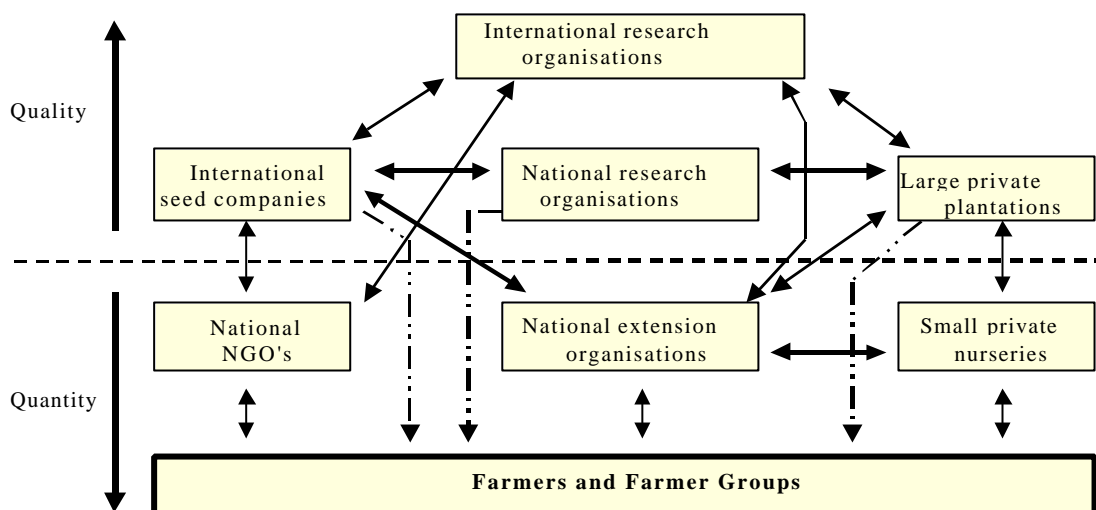


Figure 4. Model of general germplasm pathways operating in Southeast Asia (Roshetko 1999, p 222). The solid arrows indicate a lot of interaction between organisations. Dotted arrows signify weak linkages. The dotted horizontal line can be seen as a 'rough' threshold or border, across which much fewer interactions occur than within each group.

Basically there are three groups involved:

- a. **Research oriented agencies:** International research organisation; International seed companies, national research organisations, and large private plantations as closely linked and primarily concerned with **seed quality**.

Quality-focused organisations are concerned with identifying the best germplasm available for a specific situation. Among the strengths of those organisations are the evaluation of species and provenances and the development of protocols for commercial timber plantation.

- b. **Development oriented organisations :** National NGO's, national extension organisations, small private nurseries, are depicted as closely linked and more concerned with **seed quantity** (often because of lack of access to or knowledge of the importance of quality seed and the importance attached to quantitative outputs: x number of seedlings distributed to farmers, x seedlings planted).

Quantity-focused organisations are very concerned with meeting the seed demand for the programs. They are good at promoting new species or provenances and at developing "tree planting cultures" among local communities. The movement of seed resources is generally uneven from the top to the bottom of the figure; information flows in both directions. If linkages are adequate these organisations form a good partnership to develop, evaluate, and promote selected species and provenances.

- c. **Farmer groups :** Individual farmers or farmer groups are more concerned with **seed quantity**. This group acquires seed through various local pathways, mostly informal:
 - Collect from local forest, woodlots or farms
 - Exchange with family or friends

The germplasm pathways vary greatly with location and are often broken into sub-pathways that operate in semi-independence. For example, quality-focused organisations often have a

propensity to interact among themselves, as do quantity-focused organisations. Similarly, seed may be regularly exchanged between research organisations, extension organisations and NGO's within the same country (or local area), with periodic infusions of germplasm from outside organisations. Exchange linkages may also develop between organisations based on personal or professional relationships of their members.

Farmers and farmer groups generally have the weakest links to germplasm pathways. This is indicated in the figure by the *dotted lines* connecting farmers and farmer groups with quality-focussed organisations. Even linkages with NGO's and extension organisations may be weak for a number of reasons:

- remote location of farms
- lack of information
- lack of capable organisations

These local pathways operate in recurrent isolation, where farmers secure seed repeatedly from the same sources without following an appropriate seed collection protocol. Technical knowledge of tree seed procurement (*seed sources* and *seed collection*) and distribution is rudimentary and generally insufficient, and the technologies applied in production and collection of seed are mostly not efficient and do not ensure the genetic and physical quality of the seed.

Products and benefits differ widely from one tree species to another, and the right choice of seeds or planting materials may make the difference between success and failure. The fact that trees live long makes tree planting a long-term investment, and it is therefore even more important that the high quality of seeds and right tree species is chosen!

10. Germplasm delivery pathways

When improved germplasm is to be provided to farmers, what delivery pathways are currently available?

- *Distribution* (through NARS, NGOS, community based organisations, private sector)
- *Dissemination* (through farmers and farmer groups)
- *Diffusion* (informal farmer-to-farmer exchange)

The link between the demand and the supply of germplasm of a species determines the efficiency with which improved material is used. Demand from farmers is being determined using farmer surveys, to get some information on:

- *quantity* of germplasm they require
- *quality* in terms of the useful traits they desired

The demand from disseminators and distributors can be assessed through questionnaires and direct contact with various groups.

An effort has been made to document the supply side of germplasm by compiling a database of tree seed suppliers. This database was made accessible on the internet on the Information Centre on the ICRAF-homepage: <http://www.cgiar.org/icraf/inform/inform.htm>

11. Management Options

In order to improve and develop different strategies of tree management on farm, some issues, which need to be included in the research and development agenda are:

- Seedlings management on *farm nurseries* (watering, thinning, root cutting, pruning, pest and disease management, ...),

- Knowledge on species mixture
- Combining fruit trees and timber: choice of species and provenance, which plant distance is suitable etc, e.g. jack fruit (*Artocarpus*) or durian and *Paraserianthes* etc.,
- Combining understorey and overstorey, with emphasis on which species and provenance choice and how the plants react e.g. ginger grown between teak, or coffee under *Erythrina* trees, ...(which leads us to tree-crop-soil interactions; see other lecture note)
- Fertilisation: What, when, how, and how much fertiliser should be applied.
- Techniques on selecting and collecting seed

For this latter topic, some guidelines on how to select and collect germplasm from trees are published elsewhere (Dawson I and Were J, 1997. Collecting germplasm from trees – some guidelines. *Agroforestry Today*, Vol. 9 No. 2, page 7-9). Only a few of the most important guidelines are reiterated here:

- Seed collection should be representative: collect seed from at least 30 trees
- For each tree, sample different points in the crown and avoid collecting only from the lower branches. The most viable seed is often near the top!
- Ensure a reasonable spacing (e.g. 50 m) between sampled trees.
- One provenance may not reflect the species, use two or more provenances if possible.
- Collect 100-400 seedlings per provenance.
- Document the work: as a minimum following should be recorded (species name, collection date, individuals carrying out the collection, location and direction to reach the site, number of trees collected from at each site, approximate average distance at each site, a unique identifier for each collected sample.

12. Marketing / processing

- Most forestry and agroforestry activities focus on *tree* or *system productivity*. Less attention is given to the economics and marketing of agroforestry products. This situation is not a surprise considering much of the early attention in agroforestry centred on species and systems targeted for subsistence level farmers. Many of the products in these systems - fuelwood, fodder, green manure - by their nature fall outside the market structure. Agroforestry has evolved over time. Current paradigms acknowledge that agroforestry species and systems should address both farm families' income and household production needs. Timber, fruit, and other commercial oriented crops are primary components of agroforestry systems. It is now timely that external factors receive due attention.
- Farmers are often unaware of marketing opportunities and channels for their products and they need better access to advice on marketing strategies. Additionally, considerable opportunities exist to create new markets, improve post-harvesting and value added processing, and build access to lucrative international or niche markets. However, the success of such endeavours depends greatly on the sophistication of the farmers, farmer groups, local organisations and the markets in question. Before such endeavours are undertaken it is imperative that the entrepreneurial capacity of the farmers and the institutional capacity of local organisations be thoroughly assessed.

Key economic and marketing issues to consider include:

- demand analysis at both the market and subsistence level
- analysis of future and potential demand
- marketing systems analysis
- product pricing
- farmer access to price and demand information
- the Players! Identification of farmers, community based organisations, NGO's, government agencies, universities & colleges, private-sector middle men & producers

- value-added processing on-farm or at the community level
- development of win-win linkages between industry and farmers
- consider balance between local, national, regional, international markets
- markets are not forever (e.g., cloves), thus market information systems should be adequate to enable domestication efforts to respond quickly to change.

Exercise:

Imagine: A fruit-exporting factory in Thailand may want annually 50.000 tons of durian. Will this come from:

- | | |
|--------------------|-----------------------------|
| a) 5 farmers | each producing 10.000 tones |
| b) 50 farmers | each producing 1000 tones |
| c) 500 farmers | each producing 100 tones |
| d) 5000 farmers | each producing 10 tones |
| e) 50.000 farmers | each producing 1 ton |
| f) 500.000 farmers | each producing 100 kg |

Question:

What scenario would you prefer to cover the durian demand in Thailand? Why? How would you realize this?

13. High-value trees

There is a tendency now to promote high-value trees. Why should we plant high-value trees?

- Increase farmers income
- Most farmers do not (yet) apply fertiliser, insecticide or herbicide etc. A lot of added value thus has to come from the tree itself
- Markets for 'natural' products are increasing
- Even without markets high-value (and especially the 'multi-purpose tree species' can be beneficial
- A word of caution: ...one needs to be realistic with farmers.

There are different methods to obtain high-value trees and their products:

- Add value to existing trees and tree derived products (quality improvement by pruning and thinning, on-farm processing, replacement of poor performance trees)
- Gradually replace low value trees with high value tree species
- Diversify tree species on farms to reduce risks

Exercise:

- Could you make a list of five high-value tree species in your country? Please elaborate what the reasons are.
- Imagine you want to provide *Gliricidia sepium* seeds to farmers in West-Java (or another area) to promote fodder production on boundary plantations. Based on the "ICRAF tree seed supplier" database, where would you procure your seed?
- Using the same "tree seed supplier" database, where would you procure the seeds for those five high-value tree species identified above?
- What are the main reasons to pick that (or those) particular tree seed supplier(s)?
- Do you have different suggestions or not? Please discuss and critique your own suggestion!!!

III. Reading Materials

Scientific Journals

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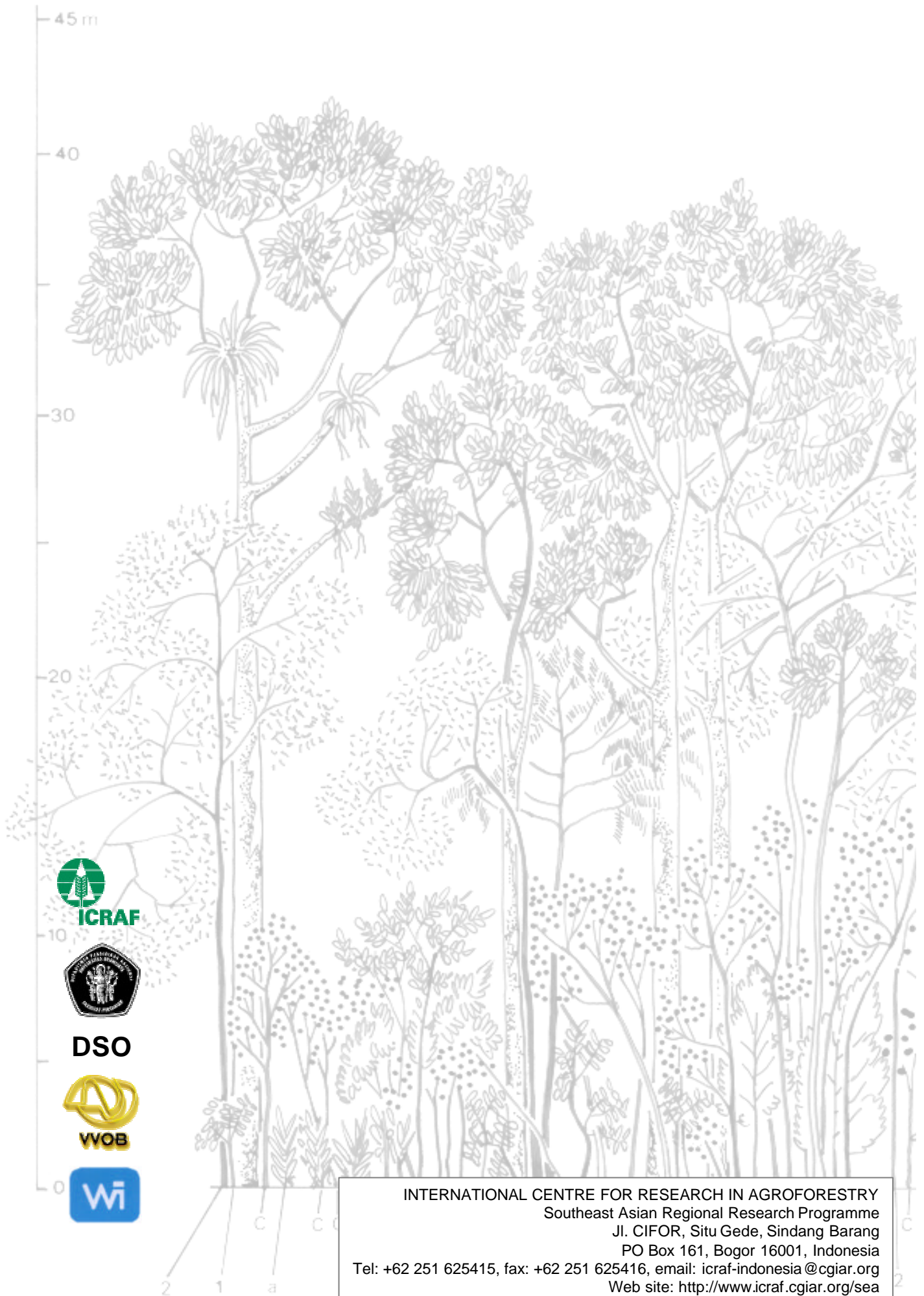
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Web site

<http://www.icraf.cgiar.org/sea>



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