

TREE NURSERY SOURCEBOOK

Options in Support of Sustainable Development

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Foreword

Tree nurseries are a key success factor in many forestry and agriculture development interventions. Over the last two decades, the World Agroforestry Centre (ICRAF), Winrock International, and University of Philippines Los Baños (UPLB) have worked with hundreds of small-scale and large-scale tree nurseries across Southeast Asia. Most of those nurseries were located in Indonesia and the Philippines. The purpose of the nurseries has varied from commercial biomass production, to land rehabilitation and forest conservation, to local capacity building and livelihood enhancement. Partners involved with operating those nurseries have included farmers, entrepreneurs, commercial firms, non-government organizations (NGOs), communities, projects, and government agencies.

The size, composition, and longevity of those nurseries have varied also. Individual- and family-run nurseries typically produced from 50 to several thousand seedlings/season. Large commercial or government nurseries produced 100,000 seedlings/season or more. On average group or community nurseries produced 10,000 seedlings/season. Simple backyard nurseries were often established with the resources that could be found locally. Most group and community nurseries were established with external support from projects, NGOs, or government agencies. Some large-scale commercial nurseries were established and operated with the latest state-of-the-art technology. Nursery production focused on timber species, MPTS (multiple purpose tree species), commodity crops (rubber, cacao, coffee, etc), or a combination of those species type. Many of the nurseries associated with projects, operated for 1 to 2 years, or ceased to exist after the project closed. However, many other nurseries evolved from project support to become independent self-sustaining and even commercial enterprises.

Through the experience of working with tree nurseries ICRAF, Winrock, and UPLB have had opportunity to assist hundreds of thousands of farmers, NGO and project staff, community workers, extension agents, researchers, and government officials enhance their technical capacity, establish successful tree nurseries, and contribute to land rehabilitation and livelihood enhancement. ICRAF, Winrock, and UPLB have been

enriched by the opportunity and gained profound understanding and insight regarding the development and evolution of tree nurseries as a component of national reforestation and tree planting programs.

This sourcebook was written to share the learning and insights from those experiences with a broader audience. It is not a technical manual. Rather the sourcebook provides interested individuals and organizations with sufficient information and general principles regarding the identification and development of the right type of nursery for their conditions. Readers are welcomed to use and share the sourcebook freely and encouraged to contact the authors with comments and inputs regarding the sourcebook or tree nurseries in general.



Acknowledgements

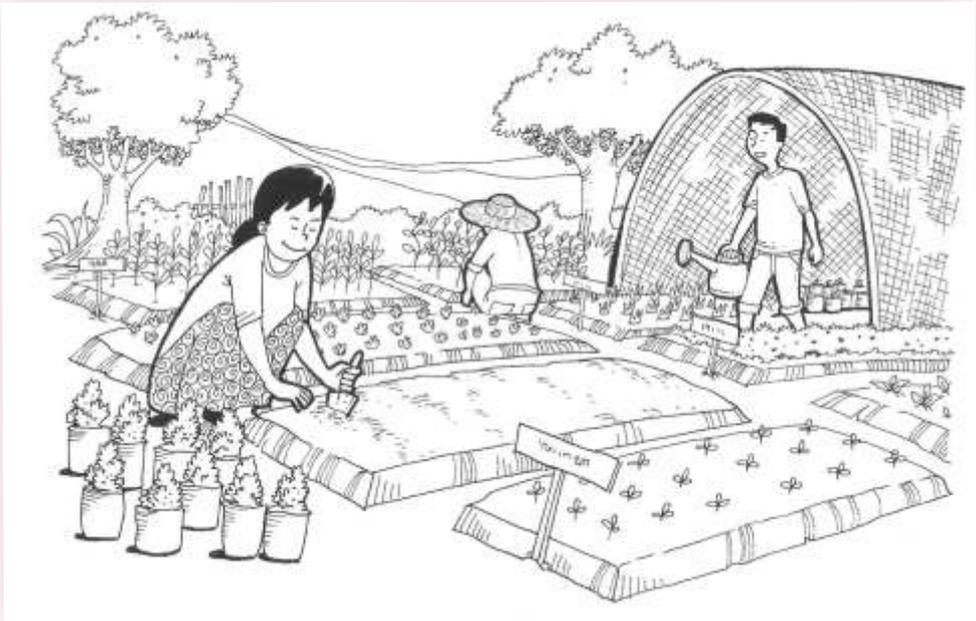
The knowledge and information shared in this sourcebook was generated with the assistance of a vast number of individuals and organizations, far too numerous to mention by name. Organizations and projects that made significant contribution to the documentation and compilation of information regarding tree nurseries include the:

- * *Nitrogen Fixing Tree Association (NFTA);*
- * *Strengthening Germplasm Security for NGOs and Smallholders in Indonesia Sub-project (Indonesia Forest Seed Project funded);*
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- * *Leuser Nurseries of Excellence Program (Leuser International Foundation, Aceh Forest and Environment Project, Multi Donor Fund (MDF) and World Bank);*
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Chapter 1

WHAT ARE TREE NURSERIES?



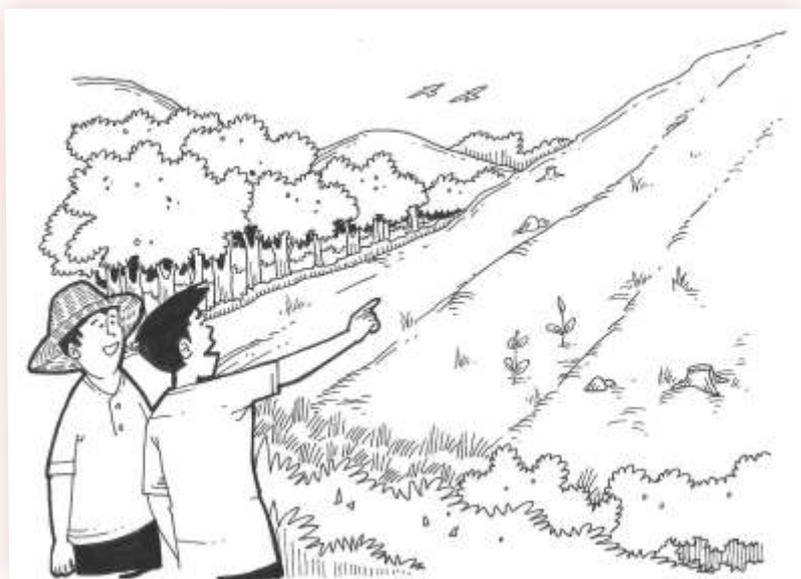
Background

A tree nursery is a managed site, designed to produce tree seedlings grown under favorable conditions until they are ready for planting. It can be an informal, small-scale arrangement or a large commercial enterprise. Nurseries vary in size, facilities (supplies, tools, equipment, etc), types of seedlings produced, and operations. They also differ significantly in quality and quantity of planting stocks produced. However, all nurseries primarily aim to produce sufficient quantities of high quality seedlings to satisfy the needs of seedling users. Users include the nursery operator themselves, individuals, community organizations, farmer groups, government agencies, non-government organizations, corporate or private customers.

Nurseries may often provide income generating opportunities for the operators and enhance the social capital, technical capacity and

leadership skills of communities. Smallholder tree nurseries also serve as important training and research ground for many smallholder farmers. In the Philippines and Indonesia, exposure to nurseries helped smallholder farmers develop those capabilities and the confidence to improve and conserve their landholdings through small-scale tree farming. Various agriculture and forestry projects undertaken in both countries include the

development of nurseries. Often, these projects spawn the establishment of self-help and self-sustaining local nurseries, which remain functional after project termination. These local nurseries may be linked in a network to meet project, community or market needs. They may also function independently to address operators' needs or serve a combination of outside and private needs.



Government and non-government agencies often provide modest support to enhance the development of local nurseries, in recognition of the spontaneous growth of local nurseries. These efforts strengthen local livelihood development and sustain public reforestation initiatives. In many areas where nursery development has flourished, farmers also developed keen interests in collecting and propagating diverse species, including indigenous trees. Such nurseries have become rich repositories of tree biodiversity.

Tree seeds germinate and trees grow readily under natural conditions. These delicate germinants (young seedlings) and young trees are exposed to adverse dry-season conditions and intense competition from other plants in natural forests or plantations. Tree nurseries can provide optimum care and attention to seedlings during their critical juvenile stage, resulting in the production of healthy, vigorous seedlings. In many cases successful reforestation requires nursery-grown seedlings, since degraded areas have unfavorable conditions making natural regeneration or direct seeding not feasible.

Good nursery operations incorporate the selection of the best quality seeds and seedlings, thus initiating tree improvement. Additionally, nurseries are advantageous in propagating recalcitrant seeds (e.g. dipterocarps and many fruit species) and species with irregular flowering/fruitletting. The seeds of these species can be stored and sown under the favorable conditions replicable in nurseries. Nurseries are also good venues for vegetative propagation operations. The cultivation of species that are otherwise difficult to propagate, can be enhanced/expanded through good nursery operations (i.e. proper seed storage, vegetative propagation, attentive seedling care).

In the Philippines, an estimated 5.4 million ha is in need of rehabilitation (Forest Management Bureau, 2002). Approximately 4.0 million ha of that area is classified as open forest, i.e. having discontinuous tree cover of 10% to 40% (Forest Management Bureau, 2007). The Government's annual reforestation target remains 50,000 ha (FAO and FMB-DENR, 2003). Using standard spacing of 2x2 m to 3x3 m, this target requires 56 to 125 million seedlings per year. The area of degraded land in Indonesia was 30 million ha. With commitment from the Government of Indonesia 6 million ha were rehabilitated between 2003 and 2008 (Indriastuti, 2009). To continue this rehabilitation trend at rate of 0.5 to 1.0 million ha per year, even at a wide spacing (4 x 4 m), will require between 312 to 625 million seedlings per year.

Extensive nursery facilities will be needed to achieve the staggering seedling demand and land rehabilitation figures cited above. Furthermore, the lands in need of rehabilitation are found across the Philippines and Indonesia and, as in most countries, often in remote areas. Experience indicates that most countries have had limited success with top-down public reforestation efforts, because the objectives and resources of local stakeholders are usually not included in the process. Governments should support, through direct and indirect means, a large number of nurseries and partners if they want to facilitate the achievement of land rehabilitation targets. Fortunately, a broad range of existing and potential nursery facilities are available in most countries.

Purpose of this Book

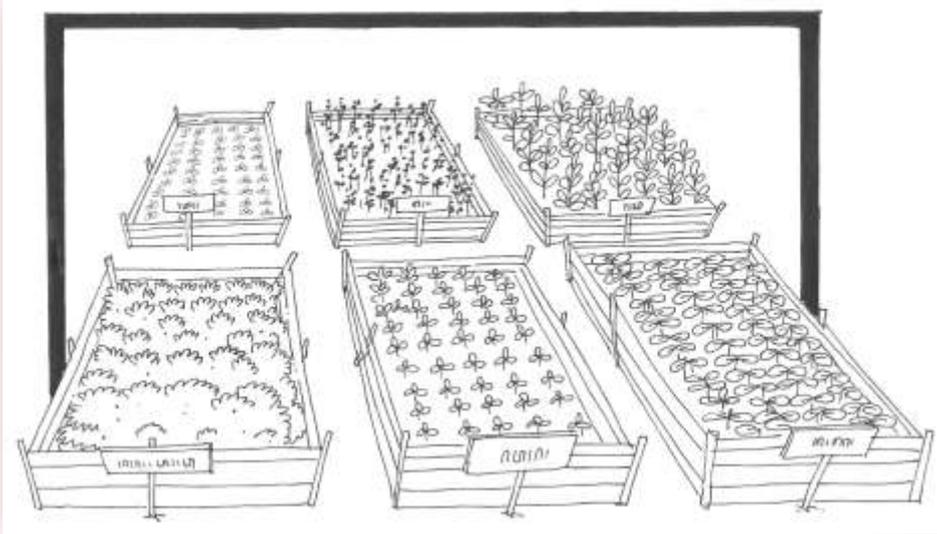
This sourcebook is written for policymakers and local governments, project designers and program implementers, government land management agencies and extension staff, NGO managers and field staff, farmer leaders and farmer groups. In short, this book is intended for any organization or individual interested in tree nurseries, reforestation or tree planting activities.

This sourcebook aims to provide readers with sufficient information, examples and general principles to identify and develop the right type of

nursery for the prevailing conditions of their respective reforestation/tree planting situations. While this document provides some technical information, it is not intended to be a complete manual for nursery management. Indeed, there are already numerous comprehensive nursery management manuals. The scope of the sourcebook is Southeast Asia, with most of the experience cited coming from the Philippines and Indonesia. The sourcebook is however, applicable to all tropical conditions.

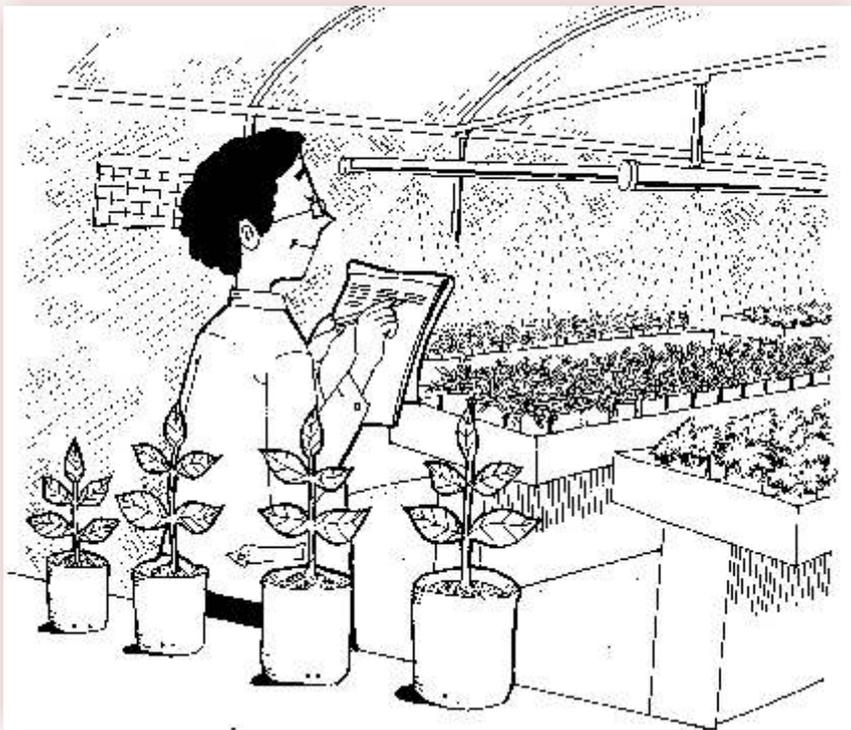
Subsequent chapters of the sourcebook include the following:

- * Nursery Types and Characteristics
- * Nursery Planning and Best Practices
- * Nursery Linkages and Dynamics
- * Choosing a Nursery
- * Summary



Chapter 2

NURSERY TYPES AND CHARACTERISTICS

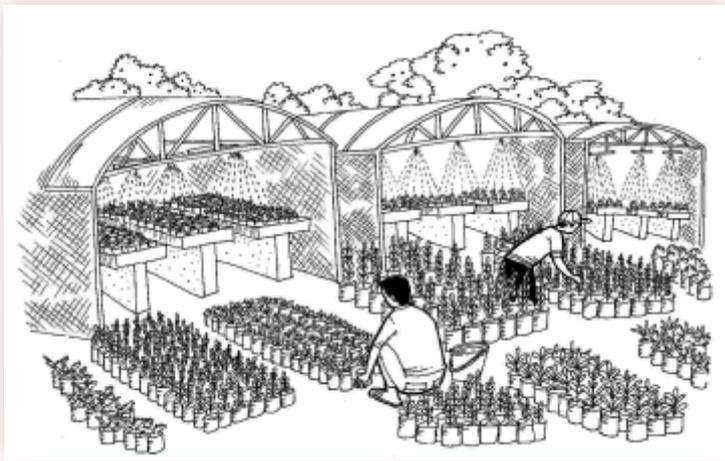


Tree nurseries vary greatly from a few dozen seedlings grown under the backyard tree to a mechanized commercial enterprise producing millions of seedlings per year. Despite the great variety, there are four major nursery types: *institutional nurseries*, *project nurseries*, *group nurseries*, and *individual nurseries*. Institutional nurseries are further comprised of three sub-categories: *research nurseries*, *government nurseries*, and *industrial nurseries*. This is not a definitive classification, and the dynamism of tree nurseries may lead to overlaps between the categories. The nursery types explored in this sourcebook will comprehensively cover all tree nursery systems or tree propagation needs.

The nursery types will be compared on the following bases: description, objectives, commercial orientation, quality and quantities of inputs and products, technology, management, research/innovations, capacity building, extension and other services, external/internal support, advantages and limitations.

Description

Research nurseries are commonly established, operated and maintained by research units of government agencies, academic institutions, corporations or international organizations. In most cases, research nurseries are designed to be permanent facilities, operating for a minimum of 5-10 years. While research nurseries vary greatly in size, they all tend to have sophisticated equipment complemented with permanent/durable infrastructures. Supplies, materials, equipment, tools and instrumentations are usually adequate to produce seedlings and diagnose/analyze seedling performance.



Industrial nurseries are commonly established and operated by large integrated wood industries. These large tree nurseries have high production capacities and generate large volumes of seedlings annually. Seedling production complies with rigid quality standards or specifications. There is strict quality control in the entire production process.

Permanent facilities in these nurseries are designed to

operate for a long period of time. Industrial nurseries can provide quality seedlings to communities of smallholder farmers including private tree farmers who want to serve as outgrowers for industrial plantations. Some industrial nurseries also produce seedlings for commercial sale. Seedlings produced by these nurseries can be horticultural species.

Government nurseries are established and operated by national and local government agencies to support reforestation and community tree planting programs. The government operations are generally large in area and scale of operations, with production capacities dictated by government targets. Other government units or communities also collaborate with the nurseries to provide seedlings to meet national or local needs. In recent years, government decentralization in many

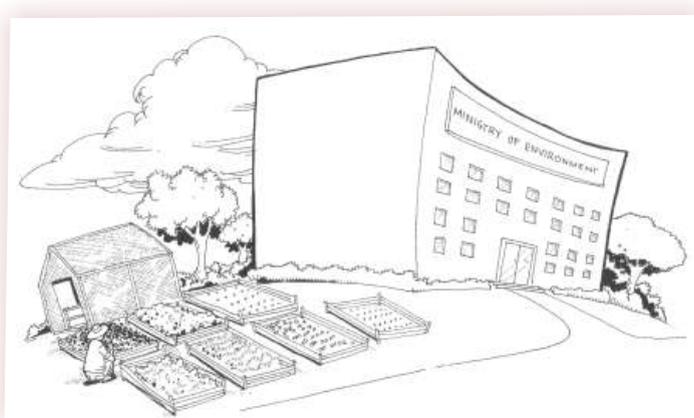
countries has resulted in the devolution of tree nurseries or local management.

Government nurseries have less intensive nursery seedling cultivation operations and a smaller manpower complement than industrial nurseries.

While there are exceptions, limited emphasis is placed on the quality of seedlings produced in government nurseries. The seedling production process is not market-driven, but is governed more by requests from government organizations or local constituents.

Project nurseries are those established and managed by projects, non-government organizations (NGOs) or development organizations. They promote a tree planting culture within target communities. The intended lifespan of project nurseries is usually 3-5 years, but may continue for longer periods. Production capacity varies from 10,000 to 100,000 seedlings per year. Organizations managing project nurseries are generally non-technical agencies employing specialists in nursery operation. Project nurseries are usually established at the community level. Community members participate in nursery planning and work in the nurseries to varying degrees; however the project or organization handles nursery management. Project nurseries have access to technical information and resources produced by institutional nurseries. They promote technical training for the target community and catalyze group nursery development.

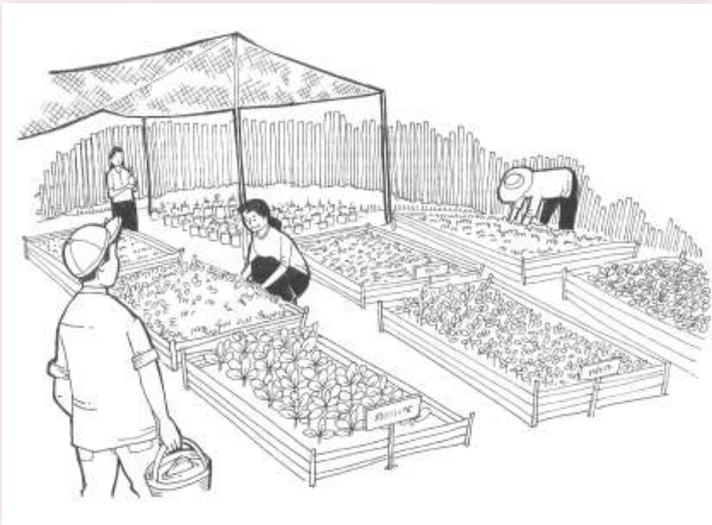
Group nurseries are established to build technical and leadership capacities of group members and expand the number of species and quality of germplasm available to group members. They produce approximately 500 to 10,000 seedlings. Nursery sizes may vary depending on their location. Small group nurseries may be operated by as few as 2 to 3 neighboring households, while the bigger nurseries are operated by groups specifically organized for such responsibilities. Both men and women have roles to play in group nurseries, from decision-making through work plan implementation. The smaller group nurseries tend to have a longer lifespan because collaboration is often based on relationships of family, friends and trust. Larger group nurseries tend to



stop operating when objectives are met or external support is terminated.

Individual nurseries are also known as household nurseries or backyard nurseries and are generally established and managed by individual farmers and/or their families. These nurseries are usually initiated to produce seedlings for planting on operators' personal farms. The house compound and farmland provide the planting sites. The size, production capacity and level of sophistication varies widely; from a few seedlings grown in recycled pots, to well-fenced nurseries of a few hundred seeds, to a thousand seedlings grown in polyethylene bags. These nurseries may distribute seedlings within the community and occasionally cater to the needs of small-scale tree planting projects. Although of limited size, individual nurseries often produce a broad variety of species.

Objectives



Research nurseries generate, develop, test and validate seedling cultivation protocols. Prototype technologies and practices are also tested. These nurseries also provide innovative ideas on improving nursery administration and management. The key activities of these nurseries includes: improving the planting stock production system, cost-

effectiveness and ensuring superior germplasm sources.

Additionally, the *research nurseries* of academic institutions serve as student training facilities on the basics of nursery establishment, operations and management. Graduate students and university researchers also use these nurseries to conduct experiments.

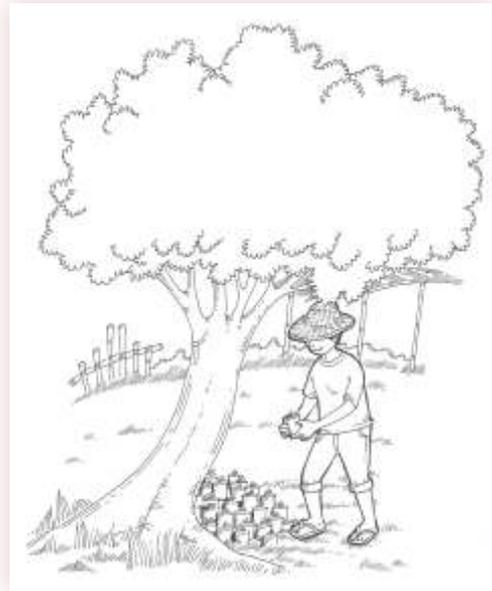
Government nurseries provide the seedling requirements of national reforestation and local tree planting programs. They may also serve as sources of seeds and seedlings, and raise interest in seedling production among would-be smallholder nursery operators. In turn, the personnel often provide training for smallholder operators.

Most *industrial nurseries* produce seedlings for their companies' tree plantation operations. Seedlings may also be for distribution to community or farmer contractors who establish additional plantation areas. Occasionally, seedlings are disseminated to communities or organizations for corporate public relations purposes. *Commercially-oriented industrial nurseries* produce seedlings primarily for market sale.

Project nurseries are geared towards reforestation and community tree planting to support sustainable rural development and livelihood enhancement. They also implement training activities to strengthen the technical and leadership skills required by communities to develop nurseries and tree farming systems.

The primary aim of *group nurseries* is to provide members with seedlings to expand their tree farming systems. These nurseries also increase the technical and leadership skills of members and provide them with the opportunity to earn supplemental income from seedling sales. Seedlings may also be provided to community members to enhance local relationships and social capital.

Individual nurseries are generally established to meet a family's need for tree seedlings. They may also generate income through seedling sales. Similar to group nurseries, seedlings may be provided to community members to enhance local relationships and social capital.



Commercial Orientation

Research nurseries usually have no commercial orientation, though some research institutions may sell excess seedlings, particularly of indigenous tree species.

While *government nurseries* are not normally market-oriented, some do sell seedlings to the public at a nominal price. In order to sustain production, government nurseries are increasingly moving towards commercialization. However, seedlings are often sold in small, limited quantities, unlike the bulk selling done by other nurseries.

Most *industrial nurseries* are operated by large integrated wood industries. They are commercial in size and scale of production. However,

seedling production is meant to satisfy the seedling requirements of the companies' tree plantation operations and is usually not market-oriented. Industrial nurseries that produce seedlings for commercial sales cater to large purchasers, but also fill small purchase requirements. These nurseries normally occupy market niches. Careful projections and market

studies are used to determine the levels of production required for profitability.

Project nurseries are rarely commercially-oriented. Seedling production is intended to meet the needs of target communities, though sometimes a nominal fee will be charged to ensure seedlings are valued by the community. Excess seedlings are sold to

customers outside target communities, with the profits providing a partial cost recovery, thereby offsetting the cost of the nursery operation.

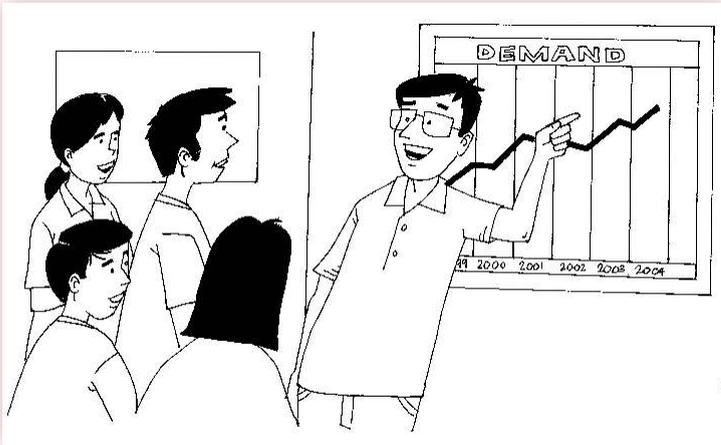
Most *group nurseries* are not established for commercial purposes, although they often sell small quantities of seedlings. However, some group nurseries may be specifically established for commercial purposes, particularly in areas where there is a market demand for seedlings.

Although established to meet family needs, household nurseries also sell seedlings in local markets. Even more than group nurseries some individual nurseries evolve towards market-orientation. Some individual nurseries become exclusively commercial enterprises and provide significant income to owner-operator. This is particularly true in areas with a strong market demand for tree seedlings. Networks of individual nurseries may form to respond to these market opportunities.

Quality and Quantities of Inputs and Products

Research nurseries often focus on developing standards of seedling quality and evaluating species, provenances, varieties and other germplasm. This is normally integrated into tree improvement or seed source selection activities. The best available germplasm is used to support these activities.

Historically, *research nurseries* have focused on a limited number of species. Recent trends show an inclination to produce seedlings of varied



tree species from diverse sources. Still, seedling production is not a priority of research nurseries; the number of seedlings produced is generally only a few hundred to a few thousand.

While there are efforts in *government nurseries* to use high quality germplasm, *research nurseries* and *industrial nurseries* employ far superior practices. Seedling quality standards are also inferior to other *institutional nurseries*. The usual practice is to focus on seedling quantity, rather than quality.

Industrial nurseries view seedling quality as of paramount importance. Rigid quality controls ensure the seedlings' maximum survival and excellent growth after planting. Industrial nurseries also attempt to maximize the quality

of production inputs. They have access to excellent seed sources and facilities for proper seed processing, handling and testing. Industrial nurseries produce large quantities of seedlings, from a hundred thousand to a million annually. The number of species propagated may be limited.

The organizations managing *project nurseries* determine the species of seedlings produced, with inputs from the target community and market considerations. Initially, project nurseries may produce a limited number of species, for which germplasm is easily available and seedlings are easily propagated. Species diversity expands as the priorities of community members become known and the skills of nursery staff increase. Timber, fruit or multi-purpose trees may be priority species, with the quantity of seedling production varying between 10,000 and 100,000. Project nurseries usually produce good quality seedlings. They often have access to, and the ability to buy quality germplasm. However, germplasm may be collected from local seed sources to encourage community participation and income generation.

To establish credibility, high quality materials may be used in *group nurseries*, particularly those supported by projects or NGOs. Group

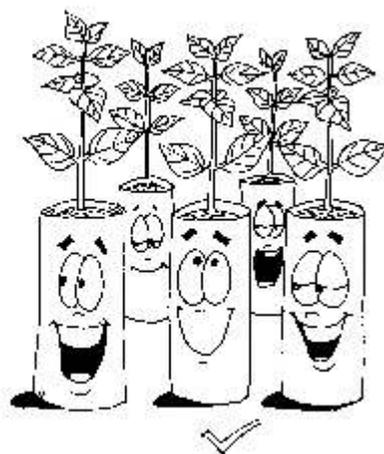
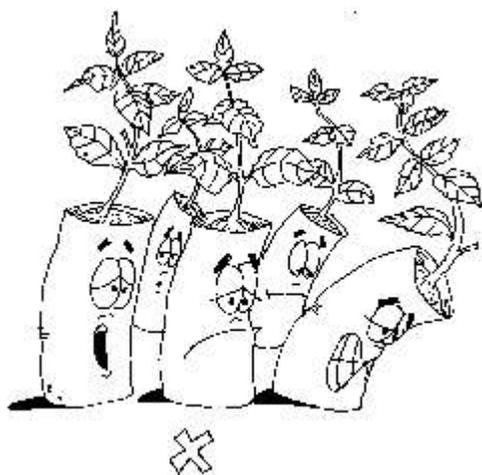


members aim to produce high quality seedlings, especially if these will be planted on their own farms. Group nurseries may produce from 100 to 10,000 seedlings, with group members selecting the species propagated. Support institutions are also involved with input and facilitation. If the group nursery is self-supporting, the germplasm used is likely to be largely locally collected. The quality of local seed can be guaranteed and enhanced by following appropriate seed collection guidelines.

The species propagated in *individual nurseries* are selected exclusively by operators, but may be severely limited by germplasm availability and the operators' knowledge and skills. The germplasm is often collected in the local area and mother tree selection is based on ease of access, not quality or standard germplasm collection guidelines. Annual seedling production is commonly 100 to 1,000 but may be as little as 50 or less. In commercially-oriented individual nurseries, annual production capacity may be as high as 10,000 to 50,000 seedlings. As commercial enterprises with reputations to uphold, those nurseries are more likely to use quality germplasm and other materials

Technology

Institutional *research nurseries* usually have adequate equipment and instrumentation for the scientific examination of planting stocks. Research laboratories are often used to compliment this work, through a more accurate assessment of seedling performance. Depending on the available budget, research nurseries can be sophisticated - with automatic sprinklers, environment monitoring sensors, well-paved beds, and retractable shades - or there may be a simple area where the minimum facilities of a research nursery are present, including seed beds, watering system, shade.



Government nurseries generally follow conventional seedling production methods. Due to financial and administrative constraints, these nurseries are often unable to adopt or maximize the use of newer technologies.

Industrial nurseries have easy access to and use the most current or appropriate technologies. They develop species-specific protocols for cost effective seedling production. The process of technological development, refinement and adoption occurs more rapidly in industrial nurseries than other nursery types, with the possible exception of research nurseries. In most cases, industrial nurseries can serve to showcase technologies.

The level and types of technologies employed in *project nurseries* is less advanced than that used by institutional nurseries, yet above that of group or individual nurseries. This enables project nurseries to efficiently produce quality seedlings and provide a learning environment for community members.

A mixture of indigenous and adopted technologies is employed in *group nurseries* (developed by institutional or project nurseries). Nurseries with external support tend to use more adopted technologies. Due to limited resources however, many group nurseries develop cost-effective, small-scale technical innovations. Available materials, such as plastic cups and bags, are commonly recycled.

Individual nurseries usually employ simple and often substandard technologies as operators generally have meager resources. Alongside this, individual nurseries often suffer from inadequate infrastructure and fencing and low levels of inputs (containers, fertilizer, compost, etc.). Excessive shading and access to water may pose a further problem. Many individual nurseries may have insufficient water supply or may depend on rain for most of their water needs.

Management

Research nurseries are manned by researchers and support staff. The organization usually has a hierarchy of authority and is highly centralized, with the research leader directing the programs and nursery activities. The nursery is managed and administered by qualified technical staff. A strict monitoring system is used to regularly evaluate staff, including a periodical assessment of their seedling performance. Documentation is meticulous and standardized.

Government nurseries have a simpler organizational structure and fewer staff than other institutional nurseries. Unskilled or semi-skilled workers are hired to meet labor needs for seedling production. Documentation is usually limited to what is required by government accounting and

auditing procedures, which are generally not useful for monitoring or improving nursery operations.

Industrial nurseries have complex organizational structures. Nursery personnel have clearly defined roles and responsibilities, with well-established lines of authority and communication. All nursery operations are under strict supervision to ensure seedling production meets quality specifications. Nursery workers receive guidance from well-trained technical personnel. Data management systems monitor inputs and outputs, especially seedling inventories.

Project nurseries are managed by staff experienced in tree propagation and nursery practices. Standard management practices and work schedules exist for nursery operations. These practices and schedules are used to train community members to operate group and individual nurseries.

Within *group nurseries* members define work responsibilities. A group leader and a nursery manager are usually chosen, and other positions, such as a treasurer, may be identified. Members agree upon work schedules and share labor. Frequently, a sub-group of members are the primary movers of the nursery. In large group nurseries, work schedules can be difficult to implement during festivals and intensive farming periods. Nursery operations are generally documented, especially in project-supported nurseries.



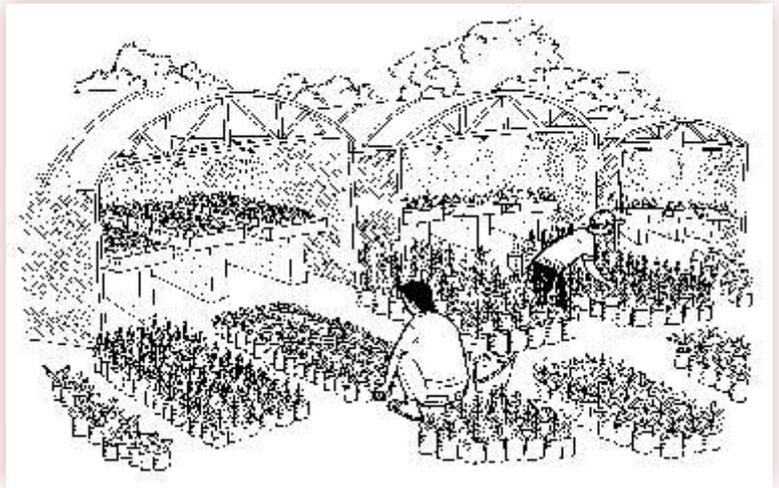
Families almost exclusively manage *individual nurseries*, with all members contributing. However, nursery establishment and management are constrained by a lack of family labor and resources. Resource-saving strategies used to manage individual nurseries include: producing seedling containers from local materials, recycling plastic seedling containers and producing bare-root seedlings. Many large *commercial-oriented individual nurseries* employ workers to help with nursery operations.

Research/Innovations

Given the resources and available staff, *research nurseries* are able to conduct a wide variety of scientific studies. Consequently, these nurseries generate substantial research results and innovations.

Government nurseries are not intended for research purposes. However, these nurseries can test and adopt technological innovations, with the focus commonly on efficient and simple mass seedling production.

Industrial nurseries can be excellent venues for developing and refining technologies used in seedling production. They have the facilities, staff capabilities and financial resources for research. Technologies may be rapidly developed by industrial nurseries and become part of standard seedling production protocols for industrial tree species. Industrial nurseries often adjust these standard protocols based on species performance in plantation sites. However, the technologies developed by industrial nurseries may not be freely shared.



Project nurseries may develop innovations for effective and cost-efficient seedling production and nursery operations at the project or community level, though they seldom conduct scientific research, except in cases where the project includes a research component or focus. These innovations hinge upon experiences gained from daily operations rather than on systematic research. Project nurseries may also provide the impetus for technical innovations to be developed in group or individual nurseries.

Group nurseries conduct their own demonstrations and trials, and may also try to develop propagation techniques for difficult-to-propagate species; particularly indigenous species. As with project nurseries, the focus of innovations is on effective and cost-efficient operations. Similar to project and group nurseries, individual nurseries conduct simple research to develop technical innovations appropriate to their operating conditions. Those activities may include testing various seedling containers, nursery media, organic pesticides, or other indigenous technologies.

Capacity Building and Management of Government

The superior facilities and highly-qualified technical staff make *research nurseries* excellent training grounds for individuals in technical specializations and managers of government and industrial nurseries. However, small-scale nursery operators seldom benefit from trainings held in research nurseries. There are some aspects of research nurseries that may benefit smallholder nursery operators, including indigenous nursery technologies adapted from other regions or improved versions.



Government nurseries are large and readily accessible, making them good venues for training and field visits by nursery operators and other interested groups. The staff in government nurseries often act as trainers, and commonly are accommodating and willing to assist.

Excellent infrastructures and facilities - complemented by well-trained technical staff - ensure that *industrial*

nurseries are outstanding training venues for basic and advanced nursery propagation techniques. Although the intensive seedling production systems used in industrial nurseries are not appropriate for most small-scale nursery operators, these individuals may still benefit from field visits to industrial nurseries.

Project nurseries are ideal venues for the formal and informal training of community members, undertaken by professional nursery staff and facilitated by staff of supporting organizations. Technical specialists from institutional nurseries may be included among the staff. Training activities run by project nurseries are effective because they include enough time for community members to share their knowledge and experience and ask questions. Periodic field visits to project nurseries after formal training are useful in supplementing the technical knowledge of community members who operate local nurseries.

Group nurseries can be used for training members and external groups. Training usually includes external support and covers environmental awareness and education, agroforestry, and organizational management.

Because the operators of group nurseries are farmers, they are frequently able to deliver very practical and effective training to other farmers. Providing farmer-operators with training of trainers (TOT) courses helps build their capacity as farmer nursery specialists.

Due to their limited size and facilities, *individual nurseries* are generally not used for formal training. However, they can provide effective farmer-to-farmer training activities. These trainings are informal and provide farmer nursery operators and farmers ample opportunities to exchange ideas and experiences. Discussions are usually focused on very practical and effective topics, procedures, and technologies. Extension agents and technicians can also learn about small-scale nursery technologies by visiting successful individual nurseries.

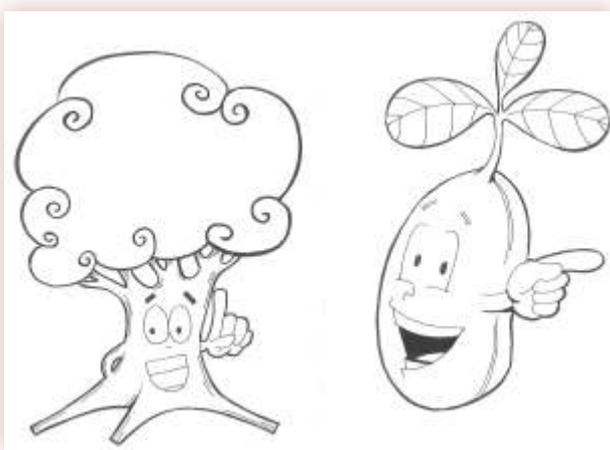
Extension and Other Services

Research nurseries generate a wealth of information used in developing extension materials for large-scale tree nurseries and smallholder nursery operators. They also establish relationships with other nurseries for information dissemination and germplasm exchange. Having little or no commercial emphasis, research nurseries earn no measurable income for their services.

The staff of *government nurseries* often serve as extension agents for tree propagation, nursery operations and post-planting management. These services are usually rendered in the nursery and sometimes through field visits to local nursery operators or farmers. Government nurseries also make the germplasm of new species written material available to local communities.

Industrial nurseries do not normally conduct extension services. However, they may provide some services to local communities, including project or group nurseries - particularly to those who serve as contract tree growers. These extension services are usually limited to tree propagation and nursery management, but may also include post-planting management.

Most *project nurseries* provide extension services to community members, particularly operators of group and individual



nurseries. These services focus on tree propagation and nursery management. In many areas where government extension services are inadequate, project nurseries may be the only reliable source of technical information. There is an emerging trend in tropical countries for non-government sources to provide extension services on species selection, tree management and product marketing. Provision of these extension services will continue to be an important role for project nurseries.

Group nursery members often provide technical assistance to farmers within and outside their community. This assistance focuses on nursery and tree management. Successful group nurseries develop reputations as technical service providers and are frequently visited by NGOs and project groups. Some group nurseries become local suppliers of tree germplasm.

Operators of *individual nurseries* can be effective farmer-to-farmer extension agents (farmer specialists). Their nurseries and farms may serve as examples for small-scale farmers. As mentioned above, being peers they are easily understood by other farmers, thus facilitating information exchange. Many individual nurseries are sources of tree seedlings and may broaden the species variety and information available to local residents and visitors.

External/Internal Support

Funding for *research nurseries* usually comes from institutions to which the nursery belongs. Some research nurseries receive external funding to strengthen their operations. Others, particularly those with foreign assistance, receive large equipment outlay and material support alongside technical assistance from hired consultants. Research nurseries rarely conduct self-financing activities.

Government nursery operations depend on government budget allocations. Fiscal policies usually limit access to cash donations and/or contributions from private organizations and individuals. However, informal cash donations or in-kind donations are sometimes provided from these sources.

Industrial nurseries have strong internal financial support, including access to credit and other funding sources. These nurseries are also in a position to use links with the scientific community to gain access to recent technologies on planting stock production.

Donor project support ensures seedling production during the life of the project or program. Due to this dependency, *project nurseries* operate under specific time periods and/or uncertain conditions. There are two strategies to deal with this uncertainty: promoting the development of group and individual nurseries; and transforming the project nurseries

into commercial operations (often referred to as nursery privatization). The successful transformation of project nurseries into commercial operations usually requires the replacement of salaried nursery staff with local residents possessing technical and entrepreneurial skills.



Group nursery members are expected to support one another in their nurseries and this may come in various forms, such as labor, materials, technologies and financial contributions. Many group nurseries access financial, technical and material support from projects and institutions. Additionally, some group nurseries earn income from seedling sales or by providing technical services to groups or individuals. Once external support ceases, group nurseries are often privatized by a sub-group of the members who are willing to continue operating with their own resources.

Individual nurseries largely depend on family resources. However, projects and institutions may provide technical and material assistance to operators, particularly during nursery establishment. This assistance usually focuses on providing good quality germplasm and training on tree propagation and nursery management. *Commercial-oriented individual nurseries* evolve as self-funded through seedling sales and the provision of technical services.

Advantages and Limitations

The advantages of *research nurseries* are:

- * assured annual budgetary support;
- * good venues for the demonstration of new technologies;
- * effective training of technical staff from other institutional nurseries; and
- * production of technical bulletins and scientific publications.

The limitations of *research nurseries* are:

- * carefully controlled conditions and sophisticated facilities do not

simulate real world situations, thus limiting the applicability of lessons learned;

- * highly dependent on institutional budgetary allocation;
- * huge initial capital and equipment outlay; and
- * farmer-oriented research is rarely conducted.

The advantages of *government nurseries* are:

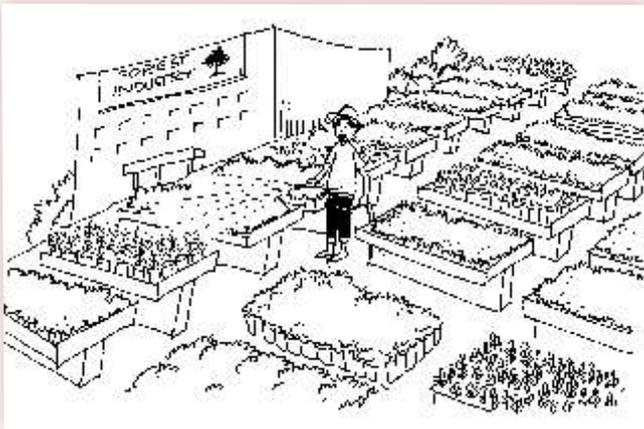
- * funds, though limited, are often assured from government allocations, thus, sustaining nursery operations;
- * links are well-established through local government networking mechanisms;
- * tree seedlings are readily available from these nurseries; and
- * there is a high potential to expand the number of species available to communities.

The limitations of *government nurseries* are:

- * delays in the release of funds and other bureaucratic procedures may hamper nursery operations;
- * limited number of species produced (in some cases);
- * limited capability to respond to communities' specific needs or species priorities; and
- * target-oriented production may mean the waste of a large number of seedlings.

Besides those listed for other *institutional nurseries*, additional benefits of industrial nurseries are:

- * assured budget and clear objectives;
- * excellent access to quality germplasm;
- * emphasis on production of quality planting stocks;
- * opportunities to test and apply new seedling production



- technologies;
- * large scale production justifies mechanization and other investments; and
- * large production rates make it possible to attain the economy of scale in production, leading to low unit production cost for seedlings.

Some limitations of *industrial nurseries* are:

- * huge initial capital investment is required;
- * high level of technical skills are often necessary;
- * number of species produced is usually limited; and
- * large scale production requires large land area for the nursery and plantations.

Advantages of *project nurseries* are:

- * external support assures seedling production during the lifespan of the project/program;
- * enhance technical skills and capacity of target communities;
- * provide access to a broad range of tree species and high quality germplasm;
- * provide impetus for innovations by group and individual nurseries; and
- * enhance social capital by promoting active community participation.

Limitations of *project nurseries* are:

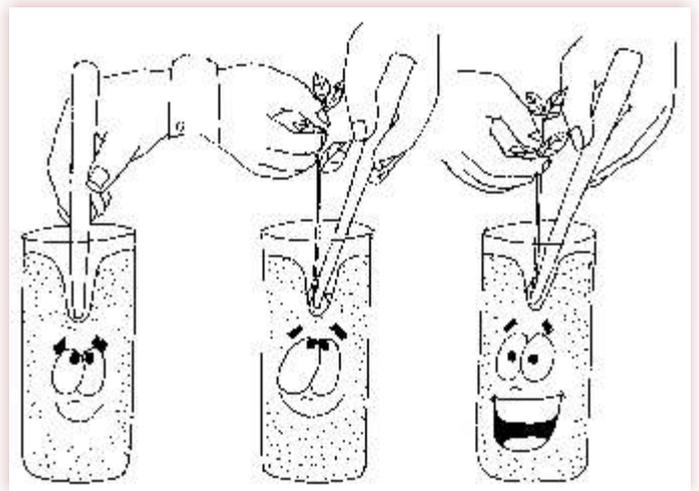
- * dependency on external support, make project nurseries unsustainable; and
- * participatory approaches require additional resources (time, staff and effort).

The advantages of *group nurseries* are:

- * increased access to a greater number of tree species and better quality germplasm;
- * social capital formation, team/institution building and leadership development;
- * effective delivery of training and technical services; and
- * effective mechanism for germplasm dispersion.

The limitations of *group nurseries* are:

- * difficulties in coordinating nursery operations and labor input within the group;
- * far distance between nursery sites and the homes of group members; and
- * inability to respond to the specific needs of all members.

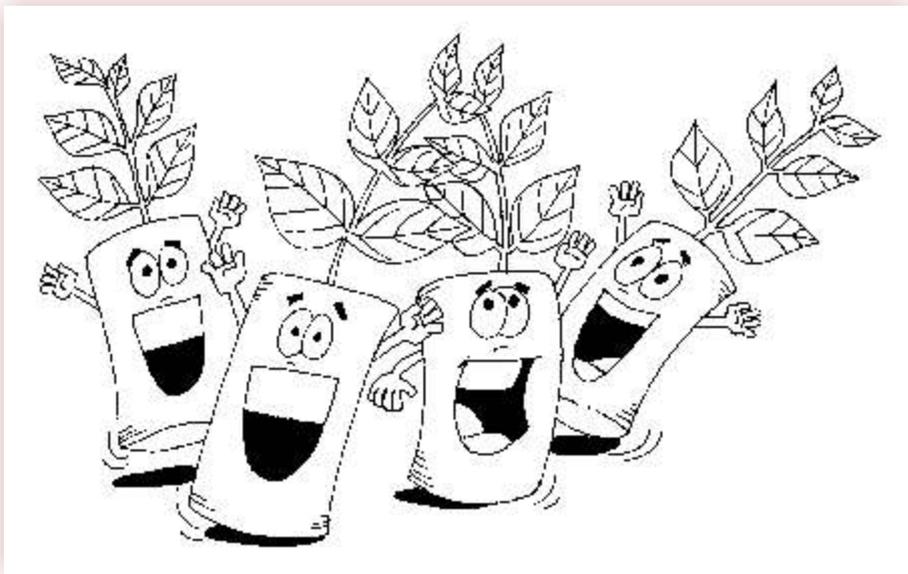


The advantages of *individual nurseries* are:

- * independent decision-making in all aspects of nursery management;
- * income generation from seedling sales;
- * produce technical innovations that are appropriate for small-scale operating conditions; and
- * appropriate venue for farmer-to-farmer training and extension.

The limitations of *individual nurseries* are:

- * seedling quality may be poor due to operators' limited resources and knowledge;
- * poor access to assistance from research, technical and development agencies; and
- * working alone results in limited access to new ideas.



Chapter 3

NURSERY PLANNING AND BEST PRACTICES



Quality seedling production depends on a sound understanding and implementation of the key principles of nursery planning and management. All of the nursery types described in this sourcebook can and should produce quality seedlings. This chapter briefly describes nursery planning and best practices for operators, to ensure the production of quality seedlings. The discussion emphasizes planning and management practices as appropriate for project, group and individual nurseries.

Nursery Planning

As with the operation of any enterprise, planning is essential for a successful and productive nursery. Factors to be taken into account are: efficient use of inputs and resources, identifying problems and potential solutions, monitoring progress, and working towards nursery objectives. Nursery plans vary in detail and in how they are implemented. Nursery plans may be formal written documents or a list of informal management guidelines. *Research and industrial nurseries* should have detailed written plans. *Government and project nurseries* tend to have formal written plans whereas *group nurseries* may have informal written documents of only a few pages. *Individual nurseries* have very informal planning, most often without any written documentation. Generally, project and group nurseries engage in participatory planning, working with stakeholders and members. Recommended elements of a nursery plan include: site selection, objectives, demand forecasting (including species and source of germplasm), inputs and scheduling, contingencies, documentation, staff training, promotion and marketing, and networking.

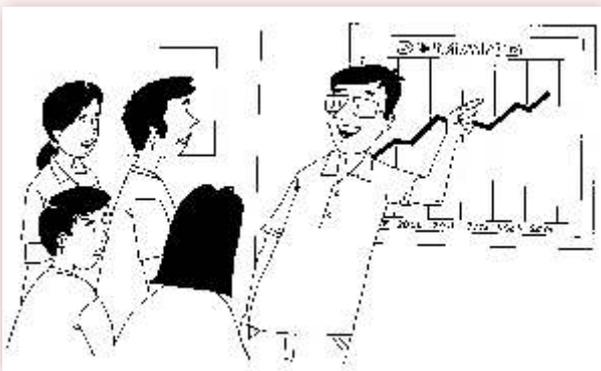
Site Selection

Factors to consider when selecting a nursery site include: i) access to planting sites and markets; ii) access to water and good soil medium; iii) flat or slightly sloping topography with good drainage and exposure to sunlight; iv) secure from animals and natural calamities such as flooding, landslides and strong winds; v) proximity to labor supply; and vi) secure land status.

Objectives

As discussed in the previous chapter, the objectives of project, group and individual nurseries generally focus on: i) seedling production to meet local tree planting or market needs; ii) local land rehabilitation; iii) income generation; and iv) technical and leadership capacity building. Plans usually specify target species, the intended use of those species

(local use, sales, etc), and the number of seedlings to be produced by each species.



Demand Forecasting

Target seedling production levels are estimated by forecasting potential demand. Demand forecasts are based on the previous experiences of nursery operators and staff, considerations of available time and resources, and information available

from the market and other sources. Key information may be obtained from seedling users: farmers, NGOs, government agencies, projects, seedling dealers, commercial nurseries and corporate farms. Demand forecasts should specify the intended production of each target species and sources of germplasm for each species.

Inputs and Scheduling

All nursery activities and their required inputs must be properly scheduled to ensure production targets and objectives are met. Inputs to be considered include: germplasm, seedling containers, tools, equipment, water, soil, fertilizers, nursery facilities, labor, transportation and capital. All inputs must be made available in a timely manner. This is especially important in areas with a short planting season. Activities which are critical to successful nursery operations and seedling production should be prioritized. For market-oriented production, this would involve the prioritization of customer and market linkages. This topic is discussed below.

Contingencies

Unexpected problems or opportunities may significantly affect nursery plans. Hence, nurseries must have contingency plans to respond to these possibilities. For example, nursery operators should know where to obtain quality seed stocks on short notice and should maintain relationships with seed dealers and other nurseries for that purpose.

Staff Training

Nursery production technologies and innovations continue to evolve. Enhancing the skills of nursery operators and staff (including day laborers) to use these innovations is beneficial to nursery productivity and efficiency. *Project, group and individual nurseries* should avail training opportunities when offered by *institutional nurseries* where most technology developments occur. Alternatively, *project nurseries* conduct training specifically for *group and individual nursery operators*. Participants should share their new knowledge with colleagues, visiting farmers, and other stakeholders. This process maximizes the distribution of new nursery technologies.

Documentation

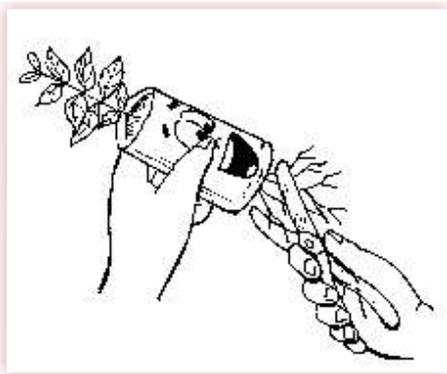
In any type of nursery, records should be made of standard practices, inputs, innovations developed, training conducted, sales, visitors, observations and other noteworthy items. Documentation helps operators, researchers and other stakeholders in planning, monitoring, and decision-making for improved nursery operations. A specific person should be chosen for documentation responsibilities. When the nursery has been established, there should be a decision on what methods, tools

and records will be kept. External facilitators from support organizations may assist *project and group nurseries* in documentation and record analysis.

Promotion and Marketing

An important factor in a nursery's success is effective promotions and marketing. Product promotion (seedlings) and services (training, consultancy) can be accomplished through various media (radio, local newspapers, bulletins, brochures, agricultural fairs and other events) and interpersonal channels. These options should be selected on the bases of the target audiences and consumers. Nurseries, especially those with training and commercial aims, should invest in promotions and marketing.

Networking



Individual and group nurseries can form networks to gain access to large and competitive markets. Networks are an effective means of exchanging information on seedling demand and availability; disseminate information regarding new technologies and innovations, and promote standardization of practices and products. To sustain network operations, benefits and responsibilities must be equitably distributed between members. Experience in the Philippines demonstrates that although nurseries may be competitors, forming a network and sharing information facilitate the operation of market channels and leads to win-win situations.

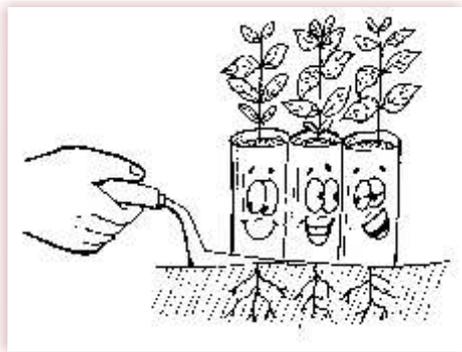
Best Practices

The best nursery practices include seed quality and management; seedling production and maintenance; and other seedling production methods. Detailed information regarding tree seed technology is provided in Mulawarman et al. (2003) and there are detailed descriptions of

best nursery practices in Jaenicke (1999), Wightman (1999) and Longman (2002).

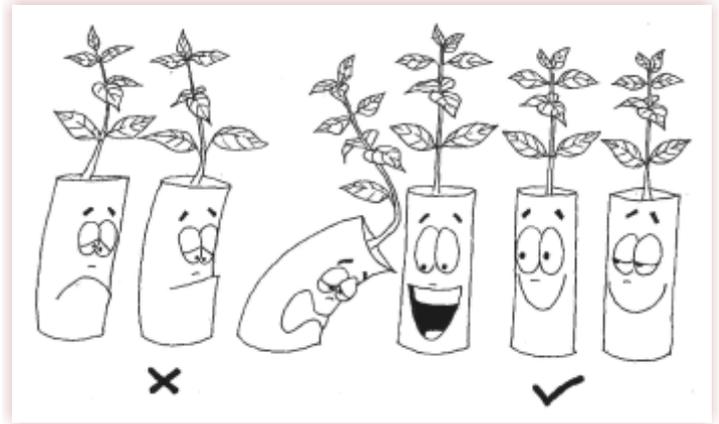
Seed Quality and Management

Quality seed is one of the key factors in producing quality trees. Seed can be collected or purchased, and should originate from superior and proven source seed stands, seed production areas and seed orchards.



Forestry professionals, seed technologists and experienced farmers can assist with identifying appropriate seed sources or seed suppliers.

Seed collection operations should follow technically sound guidelines. Only mature healthy seed should be collected. Mature seed has a uniform color, lacks physical defects and disease. Ideally, seed is collected from at least 30 healthy and vigorously growing mother trees spaced at least 50 meters apart. If this is not possible, seed should be collected from as many trees as possible and from different parts of the crown. Seed should not be collected from isolated, branchy and stunted trees.



Once collected, all seed should be transported to the nursery as soon as possible.

Orthodox seed should be pre-dried to reduce seed moisture content and avoid heat build-up associated with respiration. To facilitate pre-drying, seed should be stored in burlap sacks or other containers that permit air circulation. Plastic bags should not be used as they restrict air flow. Pre-drying can be conducted in the field. Recalcitrant seeds must retain high-moisture content and must not be dried.

Prompt seed processing is required for both orthodox and recalcitrant seed, to maintain quality and make clean seeds available. For large quantities of seeds, testing is necessary to determine viability and correctly identify seed quantities for sowing. Where seed storage is necessary, appropriate conditions must be used. Mulawarman et al. (2003) provides details regarding seed processing and storage.

Each seed lot should be labeled with the following information: species name, date of collection, location of seed source, number of mother trees and name of collector. This information should also be recorded in a separate document stored in the office. Documenting the information ensures that good seed sources are identified for repeated use and collectors are sharing their knowledge and experience.

Seedling Production and Maintenance

Besides the use of quality seed, proper nursery production and maintenance activities are essential to multiply quality seedlings. Seedling production and maintenance include the following: seed pre-

treatment and sowing; soil management; shade and water management; pricking; root pruning; pests and disease control; hardening; seedling grading and handling.

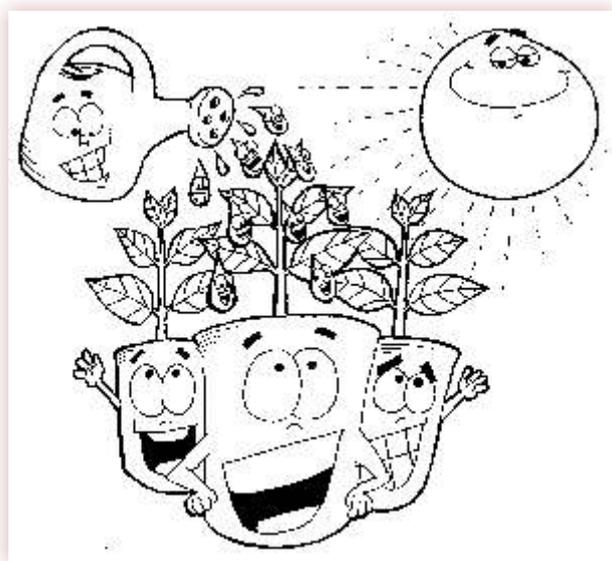
Orthodox seed should be pre-treated to promote rapid and uniform germination and growth. Pre-treatments mimic the natural seed germination process. Common and practical pre-treatments vary according to species and include: soaking in tap water, soaking in hot water, and scarification. Once pre-treated, seed should be sown immediately. Seed is usually sown at a depth equal to its average diameter and lightly covered with sand or nursery soil. Desirable nursery soils are well-drained, fertile, free of pests and diseases, and have a light texture. They are usually made by mixing appropriate portions of forest soils, sand and compost. Germination and nursery media may also require sterilization for serious cases of soil-borne pathogenic infection.

Seedlings that germinate in seed beds or boxes must be transplanted to seedling containers when they are approximately 5 cm in height and have a pair of true leaves. This process is called pricking (or pricking out) and must be conducted carefully to prevent desiccation and damage to the young seedlings' delicate roots. Roots should be positioned in containers, so that straight healthy root systems can form. Careful root management is required at all stages of seedling development. Roots should not be allowed to grow outside the container. When this occurs, the roots should be pruned.

Shade and water management should be carefully controlled to encourage quick germination and vigorous growth of healthy seedlings.

Seedling containers and nursery beds should be watered once to twice a day, based on soil and weather conditions. Germinants and young seedlings require shading to protect them from high temperatures and desiccation. Watering and shading are gradually reduced as seedlings develop, gain size and become sturdier. This process, called hardening, prepares seedlings for the adverse conditions (full sunlight and moisture stress) of planting sites.

Nurseries are managed in order to avoid pests and disease through



proper hygiene and cultural management. This includes proper ventilation, prevention of water logging, keeping tools and equipment clean and proper disposal of nursery waste, especially infected seedlings. Specialists should be consulted in cases of serious pest or disease.

Seedlings should be handled with care throughout all stages of development, so as not to disturb the soil and damage the roots. They should not be carried by the stems or leaves, rather held carefully in a container. The use of boxes and crates is recommended when moving or transporting large numbers of seedlings. Regular grading and culling should be conducted. Experience indicates 15% to 20% of seedlings are deformed, sickly or otherwise of poor quality. Such seedlings should all be discarded.

Other Seedling Production Methods

As discussed above, seed is used to propagate seedlings of most tree species. Most nurseries prefer this seedling production method. For various reasons, sufficient quantities of viable seed are not always readily available, making seed-based nursery propagation difficult or impossible. Under such circumstances, other production methods are warranted, including: wildlings, stumps, cuttings and other vegetative propagation. Additionally, when planting sites are far from the nursery, direct seeding may be a more viable tree establishment method. Table 1 characterizes these other seedling production methods. Technical information regarding wildlings is provided in GOLD Project (1998) and Pollisco (2006),

Table 1. Other Seedling Production Methods

Seedling Production Option	Species Characteristics	Comments
Containerized Seedling	Orthodox seed that is easy to propagate & readily available	Appropriate for most situations
Wildlings	Recalcitrant seed, species with irregular seed production	Care required when collecting & handling collect wildlings; collect only small wildling (10-15cm in height)
Cutting/Vegetative Propagation	Propagation is possible from roots, stems or leaves;	Produces trees that are genetically identical to mother trees; appropriate methods vary greatly by species
Stumps	Common with teak (<i>Tectonia grandis</i>) & gmelina (<i>Gmelina arborea</i>)	Appropriate when planting sites are far; cheap establishment method
Direct Sowing	Species that establish quickly and successfully compete with wood and herbaceous weeds	Requires large amount of seed; high mortality potential; applicable only on good sites

good information regarding cuttings or other vegetative propagation methods in Yaacob and Subhadrabandhu (1995) and Pollisco (2006). Useful Indonesian language vegetative propagation nursery manuals are Prastowo et al (2006) and Purnomosidhi et al (2007).

Chapter 4

NURSERY LINKAGES AND DYNAMICS

Tree nurseries are not static and solitary entities. The various types of nurseries are interdependent and maintain many dynamic linkages with each other and the tree planting/reforestation sector. Those linkages are illustrated in Figure 1. At the left of the figure, *institutional nurseries* are depicted as being a main source of the technologies, other information, and germplasm that flow to the other types of nurseries. Services, information, and materials from *institutional nurseries* are often transferred through *project nurseries* to *local nurseries* - group or individual nurseries. *Government nurseries* however may directly provide technology, material and financial support to some local nurseries. *Research and industrial nurseries* are mainly linked with other institutional nurseries, and have limited direct interaction with local nurseries. *Project nurseries*, and their support organizations, are also a primary source of financial and material support for the establishment and initial operation of local nurseries.



The right side of the figure shows that *group and individual nurseries* are not only the recipients of information and resources, but also provide a back flow of information, innovations, and germplasm. *Group and individual nurseries* are shown as having strong linkages with markets as important source of seedlings for private tree planting and government reforestation activities. *Project nurseries* also supply reforestation and tree planting activities either directly or through local communities. *Government and industrial nurseries* are important sources of seedlings for reforestation and tree planting activities (frequently vertically integrated activities); and *commercial-oriented industrial nurseries* have strong links with seedling markets. These relationships show that all nursery types are important interlinked components of national seedling supply systems and reforestation programs. Details regarding the linkages between nurseries are provided below under the topics of: germplasm, technology and information, financial and material support, seedling markets and support of reforestation programs, backflow of information, and nursery evolution.

Germplasm



Industrial nurseries are a major source of germplasm for all other nursery types. They serve this role in a number of distinct ways. First they screen and promote species for tree planting activities, often focusing on fast growing exotic species. The primary purpose of these activities may be the self-interest of maximizing the production of biomass for their integrated wood industries. Additionally, quality germplasm is made available to other farmers and other land managers through out-grower schemes. Quality germplasm may also be provided to the general public, but

this is not a major role. As high-quality germplasm is always in short supply, the amounts distributed through out-grower scheme and made available to the general public may be limited. Operators of *group and individual nurseries* often collect germplasm (seed and sometimes natural regeneration) from industrial plantations. Those activities are often permitted, if not officially endorsed.

Government nurseries, often in collaboration with extension agencies or other institutional nurseries, deliberately promote specific species and make germplasm of those species available to other nurseries. Even after a species has been widely disseminated into local communities,

government nurseries and their partners may continue to make germplasm of the species available to support tree planting activities.

Project nurseries disseminate the seed they receive from institutional nurseries to group and individual nurseries. Project nurseries also help diversify the species and germplasm used locally by screening and promoting species (particularly indigenous species) that meet household or market needs. Many *group and individual nurseries* also promote indigenous species and species diversity to meet household needs. They propagate small quantities of many species, often including a broad diversity of both exotic and indigenous trees. Indigenous species are often collected as wildlings, maintained in local nurseries, and then made available to seedling markets and reforestation/tree planting programs. Germplasm of these indigenous species flows back to project and institutional nurseries. With time, the diversity and quality of germplasm available in project and local nurseries tends to improve.

Technology and Information

Most nursery technologies and related information originate from institutional nurseries. The development and testing of nursery technologies is the main objective of research nurseries and an operational concern for industrial nurseries. In general, institutional nurseries freely share their technologies and information with other nurseries. Group and individual nurseries, usually small-scale enterprises with limited capital and infrastructure, are often unable to utilize the latest and most advanced technologies. Government and project nurseries often help to address this situation by developing general recommendations for the operation of nurseries at the local level. Successful group and individual nurseries have a strong ability to adapt and improve existing technologies to meet their specific needs. Group and individual nurseries freely share their technical innovations and experience (local knowledge) with other nurseries. In fact, many successful group and individual nurseries serve as mentors to other local nurseries and interested stakeholders. Government and project nurseries may collect details on local nursery innovations, not for use in their own



facilities, but to share with farmers and communities interested in developing nurseries.

Financial and Material Support

During their establishment phase, the first few years of operation, most group nurseries and many individual nurseries receive some sort of financial and material support (seedling containers, tools, fertilizer, etc). This support is primarily provided by project nurseries and is often a main purpose for the projects' existence. The funds for support of local nursery development are provided by the projects' external donors. Some government nurseries also provide material support to local nurseries, and may provide limited amounts of financial support in some cases. The funds for this support are allocated from the mother institution or central government. There are also cases of local governments (provincial or municipal) providing direct support to local nurseries. After the establishment phase, many group and individual

nurseries are largely self-financed. This is achieved through seedling sales, providing technical services, recycling all possible materials, and limiting cash expenditures.



Seedling Markets and Support of Reforestation Programs

In most countries seedling markets are large, diverse and beyond the direct control by any one entity.

However, where large or systematic reforestation programs exist, the

responsible government agencies and program implementers have a significant influence on species demand, seedling demand, and germplasm flows. The primary objective of many government nurseries is to support national reforestation and other tree planting programs. However at the local level, particularly in rural or remote areas, group and individual nurseries are often the main source of tree seedlings and thus key supporters of reforestation and tree planting activities. In many cases local nurseries sell seedlings to government agencies, contractors implementing reforestation activities, or private companies and individuals interested in tree planting. Sometimes group or individual nurseries operate as quasi-government organizations, committing nearly 100% of the

¹ *In situations where seedling quality regulations exist local nurseries often meet quality specifications, but are unable to complete the 'certification process'. In these cases, local nurseries often provide seedlings to certified government seedling suppliers who do not even operate a nursery. These suppliers are only middlemen adding costs and quality to the seedlings. Such restrictive regulations serve only to distort seedling pathways/markets, increase program costs, and reduce seedling quality through unnecessary handling.*

production capacity to government or contractor orders¹. To summarize, in many cases government and local nurseries are key suppliers of seedlings for national reforestation and other tree planting programs. Industrial nurseries indirectly support national reforestation program by establishing large plantations as part of their integrated wood industries. Commercial-oriented industrial nurseries sell large quantities of seedlings to enterprises and individuals interested in tree planting. This process also indirectly supports reforestation efforts. Project nurseries support reforestation and tree planting programs directly and through support of local communities.

Backflow of Information

Linkages between nursery types are not one directional from institutional nurseries towards local nurseries. Group and individual nurseries provide feedback on nursery technology and information packages. Their assessments, often informal, are shared with project and government nursery sponsors, who in turn share this information with other institutional nurseries and concerned stakeholders. Project nurseries also provide their own feedback on technologies and information packages to institutional nurseries. Project, group and individual nurseries also contribute useful information regarding technical, training and species needs at the local level. Additionally, successful group and individual nurseries are a valuable source of information regarding the technical innovations that are appropriate for small-scale local nurseries operating with no or very limited financial resources. Those nurseries can also provide important guidance on how to implement effective extension and training activities, particularly those that utilize farmer-to-farmer approaches. All of this feedback is valuable to help project and institutional nurseries enhance their understanding support to local nurseries. However, most local nurseries are unaware of the value of their knowledge and will not provide feedback unless asked. Project and institutional nurseries need to conduct participatory appraisals to compile this valuable local knowledge.

Nursery Evolution

Group nurseries are often established under the assumption that after a few years of external support all of the nurseries will become self-sustaining. This rarely, if ever, happens. After a few years many group nurseries stop operating. This process, erroneously considered failure, is vital to the development of a health national seedling supply system and should be understood. Group nurseries are usually organized with strong outside influence to impart seedling propagation and nursery management skills to target participants, for the specific purpose of supplying tree seedlings to meet local needs. For the sake of efficiency

the 'groups' organized are of medium to large size, contain 10 to 25 individuals, and sometimes more. After one or two years interest and commitment to the groups nursery often wanes, because: i) the seedling needs of group members may be largely satisfied; ii) nursery skills among group members have significantly improved; and iii) for most group members nurseries are not a top priority. At this point group nurseries disband, not due to failure, rather because they have achieved their primary objectives – seedling supply and capacity building. In many cases group nurseries also engender a tree planting culture. An unexpected, yet common, result of group nurseries disbanding is the evolution of new local nurseries. Former group members who are keenly interested in seedling production and having developed appropriate skills often establish new nurseries. These may be individual nurseries or 'small group' nurseries that are based on existing relationships and mutual visions between friends or relatives (frequently 2-3 individuals or families). These new nurseries are frequently well operated, produce quality seedlings, and are strongly commercial and/or community-service oriented. In many cases the group nurseries are privatized by the group members most interested in sustaining its operation.

Another common evolution is that the staff of project or government nurseries often starts individual nurseries. These individuals generally have developed good nursery skills and firm linkages with local or national seedling markets. Project and some government nurseries play an important role in the evolution of local nurseries. They often serve as the nucleus of a network of group and individual nurseries. This central role and function is often fleeting. Frequently project nurseries are out-survived by some of the group and individual nurseries that evolved from their support. In some cases, once outside support ceases, even project nurseries are privatized by staff members to continue seedling production to meet community and commercial needs. Government nurseries undergo a different form of evolution. They may fall into disrepair through neglect or inactivity and then are revitalized when the demand for tree seedlings increases. The role of government nurseries as the nucleus of a network of local nurseries fades and expands as interest in reforestation and tree planting wane and wax.

Chapter 5

CHOOSING A NURSERY

Selecting a nursery type is not a straightforward decision. A number of factors should be considered to ensure the appropriateness of the nursery type. This chapter is intended as a decision-making aid, to help individuals and organizations identify the appropriate nurseries by their conditions and for their intended objectives. Important selection criteria will be used as a basis for comparing the main nursery types already examined: research, government, industrial, project, group and individual. The selection criteria are arranged into four main headings: goals and functions, operational features, management inputs, and external factors. Table 2 provides a comparison of the criteria by nursery type, followed by a discussion of the conclusions reached.

It should be noted that there is rarely a single 'best' nursery type for any given situation; any number of types often serve the need. However, to maximize the chance of success all possible options should be considered before selecting a nursery type.

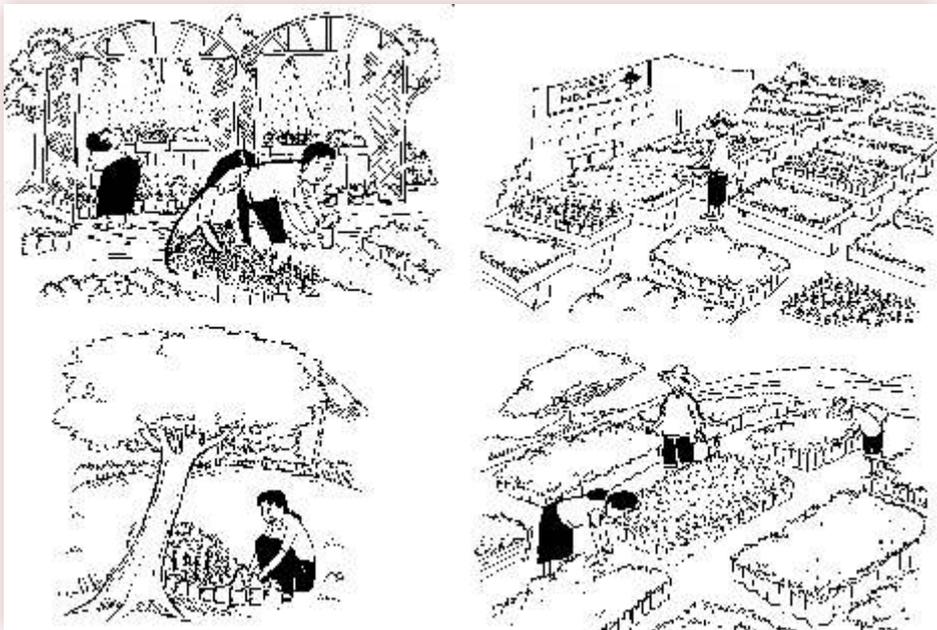


Table 2. Comparison of Nursery types by selection criteria

Selection Criteria	Nursery Types			
	Institutional	Project	Group	Individual
Objectives and Functions				
Technology generation	+++	++	++	+
Technology dissemination	++	+++	+++	+
Technology innovation	+	++	+++	+++
Capacity building	++	+++	+++	+
Income generation	+	+	++	+++
Environmental education & awareness	+++	+++	++	+
Operational Features				
Production capacity	+++	++	+	+
Duration of operation	+++	++	+	++
Quality of planting stocks	+++	++	+	+
Species diversity	+	++	++	+++
Management Inputs				
Financial costs	+++	++	+	+
Infrastructure	+++	++	+	+
Human Resources	+++	++	++	+
External Factors				
Policy support	+++	+	+	+
Credit access	+++	n/a	-	-
Development assistance	+	+++	++	+

+++ means high

++ means medium

+ means low

- means none or non-existence

n/a means not applicable

Goals and Functions

Technology generation

Technology generation refers to nurseries' abilities to produce new technologies for various nursery operations such as propagation, management and administration. Institutional nurseries have a high potential for technology generation, owing to their emphasis on research, particularly the development of new technologies for government reforestation and corporate tree planting programs. Project and group nurseries have a limited capacity to generate new nursery technologies, due to their limited scope and clientele. The same is true for individual nurseries which rarely focus on developing new technologies as they are constrained by limited financial support and resources.

Technology dissemination

New nursery technologies should be shared with intended users and beneficiaries. Project and group nurseries have a high potential for

technology dissemination because of their farmer-friendly atmosphere and frequent linkage with other project, group, and individual nurseries. Farmers readily share new technologies among themselves. Farmer-to-farmer communication is generally very clear and efficient as they empathize with each others' conditions.



Project and group nurseries may have only moderate capacities to disseminate technology because of their limited linkages with other nurseries and farmers. Institutional nurseries also have a moderate capacity for disseminating technology, and primarily assist other institutional nurseries or project nurseries. Individual nurseries do not normally disseminate technologies, rather they benefit from the technologies used by group nurseries.

Technology innovation

Group and individual nurseries are small-scale enterprises with limited capital and infrastructure investment. To compensate for these limitations, they often adapt existing technologies to meet their specific needs. Adapted technologies are both indigenous and generated externally. The opposite is true with institutional nurseries, which generate 'new' technologies to address specific conditions while giving little attention to innovation of existing technologies. Project nurseries demonstrate an intermediate capacity in this respect.

Capacity building

Capacity building refers to both formal and informal trainings. Project and group nurseries are common venues for training farmer-groups and other organizations. Farmers find group nurseries conducive to learning, as they provide an informal setting. Institutional nurseries cater to formal trainings for technicians and academic institutions. Individual nurseries have a strong potential use in farmer-to-farmer training, but are rarely used for this purpose as they have a limited area and facilities. Individual nurseries that serve as training venues are often commercially-oriented and resemble project or group nurseries.

Income generation and market orientation

A nursery's income generating capacity closely follows its market orientation. Individual nurseries, despite the majority of them being of small size and limited seedling production, have a strong capacity to generate income. This is obviously a key motivating factor for farmers who develop nurseries. Group nurseries generally focus on capacity building and seedling production. However, some group nurseries may be specifically organized for market-oriented seedling production and can generate significant incomes for members. Among the institutional nurseries, only market-oriented industrial nurseries have a strong income generating capacity. Government and research nurseries are not designed for income generation, and they often have fiscal restrictions on commercial endeavors. Project nurseries, on the other hand, generally have no income generation objectives, although they may aim to develop the income generation capacity of group and individual nurseries.

Environmental education and awareness

Nurseries are excellent learning centers for environmental awareness. They represent a microcosm of the environment, where even small children can appreciate the benefits of trees. Institutional and project nurseries create high environmental consciousness as they are part of environmental education concerns of most government and project nurseries. These nurseries are also repositories of various species and genetic resources, thus contributing to biodiversity conservation. Group nurseries also frequently promote environmental conservation and protection among their members to enhance their farms and livelihoods. Individual nurseries contribute little to environmental awareness; however this is not one of their priorities.



Operation Features

Annual production capacity

Annual seedling production varies according to nursery type and is determined by known and anticipated demand. Industrial and government nurseries have very high production targets relative to other nursery types. Industrial nurseries frequently produce more than 1,000,000 seedlings annually while government nurseries produce

from 100,000 – 1,000,000. Project nurseries have intermediate annual production capacities of 10,000 to 100,000 seedlings while group nurseries generally produce 500 to 10,000 seedlings and individual nurseries between 100 and 1000 seedlings yearly. However, some group nurseries may produce 20,000 to 50,000 and market-oriented individual nurseries may produce 100,000 seedlings with the assistance of hired staff. Exceptional individual nurseries are known to produce over 1,000,000 seedlings. Small-scale individual nurseries may produce less than 50 seedlings. Research nurseries may produce very few seedlings, from 100 to 1000, as their primary intention is to generate information and technology, not seedlings. Some research nurseries may produce an intermediate quantity of 10,000 to 50,000 seedlings.

Duration of operation

Organizational missions or objectives determine the length of nursery operations. Institutional nurseries have the longest duration. They are usually designed to be long-term facilities, providing continuous seedling production capacity. Other nursery types are designed to meet specific seedling production targets and are not meant to be permanent. Project nursery operations end when external support is terminated. They generally operate for 3-5 years. Group nurseries usually last 1-2 years, as groups tend to disband after nursery objectives are achieved or members have sufficiently enhanced their technical capacity. Group nurseries that are privatized and evolve towards market orientation have longer durations of operation. Individual nurseries are more dynamic, usually operating for one production cycle to several years. Often individual nurseries operate intermittently over a number of years. Market-oriented group and individual nurseries have a longer lifespan that are directly linked to market demand and opportunity.

Seedling quality

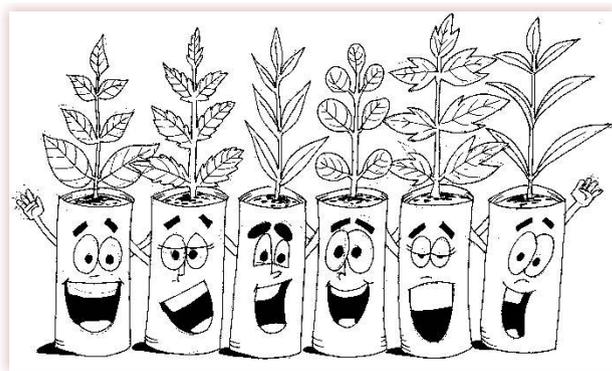
Seedling quality is determined by a nursery's technical capacity and access to quality germplasm. Research and industrial nurseries usually produce the best quality by using the best technologies/germplasm and following strict production standards. Among other nursery types, project nurseries produce



good quality seedlings. Government, group and individual nurseries produce seedlings of varying quality depending on their technical capacity and other circumstances.

Species diversity

Species diversity tends to be inversely related to the scale of nursery operation. Large-scale institutional nurseries traditionally focus on producing a large number of seedlings, of a limited number of



economically important species. In contrast, project and group nurseries produce a more diverse group of species within their smaller facilities to meet the multiple socio-economic and environmental objectives of different stakeholders. Individual nurseries tend to have the highest diversity as they produce few seedlings of many species to meet household livelihood needs and exploit various on-farm planting niches.

Management Inputs

Financial costs

Monetary capital is necessary for the establishment and operation of all nursery types. Institutional nurseries are by far the most expensive due to requirements of capital investments in land, facilities and staff costs. Comparatively, project nurseries cost much less to establish and operate, but they still require a dedicated budget. Group nurseries require much lower financial costs as they operate on the basis of volunteer members. In many cases, group nurseries receive financial support from projects or institutions. For individual nurseries, there are few direct financial costs required for establishment or operation. Market-oriented group and individual nurseries generally have higher operating costs that are self-supported through market sales and service provision.

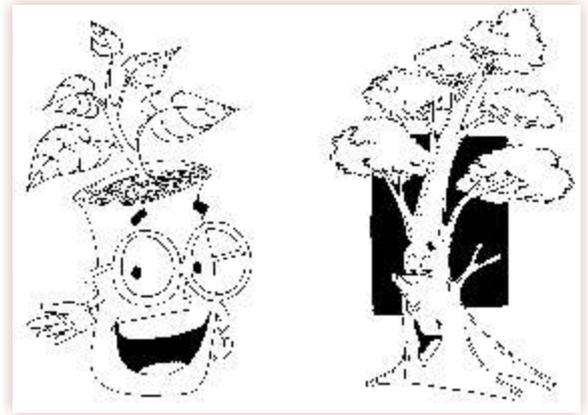
Infrastructure

Institutional nurseries require elaborate infrastructure and permanent facilities to efficiently produce large quantities of seedlings and sustain continuous operations over a long time period. Such facilities include greenhouses and shade houses, watering systems, a power supply, storage and office space, as well as vehicles. Project nurseries require an intermediate level of infrastructure, less complex than institutional nurseries. Group nurseries may have little infrastructure, while many

individual nurseries may have none at all. Market-oriented group and individual nurseries generally have an intermediate level of infrastructure similar to that of project nurseries.

Human Resources

Here human resources refer to administrators, managers, technicians and laborers who support and implement nursery operations. Institutional nurseries have high human resource needs, due to the sophistication and size of their operations. Project nurseries have lower human resource requirements, but still require professional staff and managers. Group and individual nurseries' human resource requirements are provided by group members and household members. Some commercially-oriented group and individual nurseries may hire nursery laborers.



External Factors

Policy Support

Government policies and regulations in most countries support reforestation and tree planting activities and directly or indirectly encourage the development of tree nurseries. Similarly, many countries have or are developing certification or accreditation programs for fruit, horticultural and forest seedlings and nurseries. These government policies and programs may or may not explicitly favor one type of nursery over another. However, implementation favors larger nurseries. Government managers prefer to deal with one or a few seedling supplier, rather than many. Institutional nurseries are best situated to take advantage of the opportunities created by these policies and programs because of their large seedling production capacity and existing links with government agencies. Most project, group and individual nurseries have limited, weaker access to the benefits of government policies and programs. However, by their presence project, group and individual nurseries have great potential to meet the seedling demands and specific priorities of local area. Some government agencies are beginning to recognize the advantages and potential of local small-scale nurseries.

Access to Credit

Institutional nurseries are the only nursery type with access to financial credit. Normally, they have assets that can be used and recognized as collaterals for loans. Project nurseries have secure internal financial support and are not interested in accessing credit. Operators of groups and individual nurseries generally have limited assets that can qualify as credit collaterals. Few small-scale operators seek credit from formal financial institutions. If they need capital they will first borrow from members, family or friends; and then from local informal credit lenders.

Development Assistance

Bilateral, multilateral and development organizations serve as major source of development assistance for tree planting and nursery establishment. Project nurseries usually have direct support from development assistance including access to additional support to expand their activities. Group and household nurseries often access development assistance through project nurseries or project supporters. Individual nurseries have less access to assistance due to their small size and the fact that they are operated by a single family. Government or research nurseries may be supported through bilateral development assistance. Industrial nurseries are usually ineligible for development assistance.

Summary

Nurseries vary greatly in size, facilities and operations. They also differ significantly in quality and quantity of planting stocks produced. However, all nurseries aim to produce sufficient quantities of high quality seedlings to satisfy the needs of seedling users – who might be the nursery operator themselves (individuals or groups), community organizations, farmer groups, government agencies, NGOs, or corporate or private customers. Nursery production varies from a few dozen seedlings grown in the backyard to a mechanized commercial enterprise producing millions of seedlings per year. Despite the great variety of possibilities, there are four major nursery types: institutional nurseries, project nurseries, group nurseries, and individual nurseries. Institutional nurseries are further divided into sub-categories: research nurseries, government nurseries, and industrial nurseries. This is a practical not definitive classification, and the dynamism of tree nurseries leads to overlaps between the categories.

Tree nurseries do not operate in solitude. The various types of nurseries are interdependent and maintain numerous dynamic linkages with each other and the tree planting/reforestation sector. Institutional nurseries are a main source of technologies, other information, and germplasm that flow to the other types of nurseries. Those inputs from institutional nurseries are often transferred to local nurseries (group or individual nurseries) through project nurseries. Some government nurseries also directly provide technology, material and financial support to local nurseries. Research and industrial nurseries are mainly linked with other institutional nurseries, and have limited direct interaction with local nurseries. Project nurseries, and their support organizations, are also a primary source of financial and material support for the establishment and initial operation of local nurseries.

Group and individual nurseries are not only the recipients of information and resources. They also provide a back flow of information, innovations, and germplasm to project and institutional nurseries and are important sources of the seedlings for many tree planting and reforestation activities. Project nurseries also supply reforestation and tree planting activities either directly or through local communities. Government and

industrial nurseries are important sources of seedlings for reforestation and tree planting activities (frequently vertically integrated activities); and commercial-oriented industrial nurseries have strong links with seedling markets. All nursery types are important interlinked components of national seedling supply systems and reforestation programs.

Which nursery type is best for a given individual, organization, or situation depends on a broad range of nursery characteristics, including: objectives, commercial orientation, quality and quantities of inputs and products, technology, management, research/innovations, capacity building, extension and other services, and external/internal support. Other factors to consider when selecting a nursery type include access to: germplasm, technology and information, financial and material support, and seedling markets. This sourcebook provides detailed information regarding nursery characteristics and related factors to assist interested individuals and organizations identify and select the right nursery for their situation.

Glossary of technical terms

Containerized seedling

A seedling grown in a container, usually a bag or pot.

Cutting

A plant part (usually stem, root or leaf) that is used to produce a new plant through vegetative propagation methods.

Direct seeding

Establishing plants in a field, garden or forest by sowing or planting seeds.

Genetic resources

1) Species, subspecies, or other genetic varieties of a plant, animal, or microorganism that currently or potentially provides goods and services. 2) Germplasm that includes the entire array of cultivars of a species, related wild species in the genus, and hybrids between the wild and cultivated species.

Genotype

Genetic constituents of an individual tree which, in interaction with the environment, largely controls tree performance. Genotype is inherited by its progeny. Generally, trees with good genotype produce good progeny.

Germinant

A young plant recently developed from a germinated seed, usually still succulent and vulnerable to desiccation.

Germplasm

Genetic material (seeds, seedlings, wildings, or vegetative material) used for the purpose of plant propagation and/or conservation.

Grading (seedling grading)

The process of separating seedlings based on their physical quality, maturity, and size, or other phenotypic (visible) characteristics.

Hardening (hardening off)

The process of gradually exposing a seedling in a nursery to harsher conditions (less moisture, higher temperatures, full sunlight, and the elimination of fertilizer application) to prepare it for planting in the field.

Nursery (tree nursery)

A place where plants are propagated and grown to the desired size.

Orthodox seed

A type of seed with a hard, impermeable coat that can be dried to a low moisture content and stored for long periods. Dormant when dried, orthodox seed will start to germinate only under favorable physical and physiological conditions.

Outgrower

An individual, group of farmers, or organization that grows forestry, agricultural, or horticultural commodities under contract with corporations or for sale on the open market. Crops commonly produced by outgrowers include wood biomass, sugar cane, oil palm, rubber, and coffee.

Phenotype

The observed characteristics of a tree, the sum of the attributes that result from interaction of the genotype and the environment.

Plantation

An area of land on which trees or other crops are planted to produce a specific commodity. Most plantations are monocultures producing a single commodity. However, plantations may also produce multiple commodities or products.

Post-planting management

Management practices applied to a tree or stand of trees after planting, including: weed control, fertilizer application, enrichment planting, intercropping, pest and disease control, pruning, and thinning.

Pre-drying (pre-dried)

The process of drying seed or fruit for a short period immediately after collection to reduce weight, improve quality, and reduce risk of degradation before transporting the seed or fruit to a central location for processing.

Pre-treatment (pre-sowing treatments)

Methods or processes applied to seed to overcome dormancy or hasten/improve germination.

Pricking (pricking out)

The process of transplanting a germinant from the place it germinated to another container or bed, to provide more room for the germinant to develop into a healthy seedling or mature plant.

Provenance

The geographic origin of a plant. Provenances usually have distinct, heritable genetic characteristics (genotype).

Recalcitrant seed

A type of seed, usually large and fleshy, that cannot be dried to a low moisture content. Recalcitrant seed cannot be stored for long periods and should be sown soon after ripening.

Scarification

Processes used to overcome the physical or mechanical dormancy of hard and thick seedcoats or fruit shells, by cutting or scraping through the seedcoat or fruit shell with a knife, metal file, or abrasive material to allow water absorption.

Seed

Generative/reproductive material of flowering plants that result from pollination or female flower.

Seed orchard

A stand of trees specifically established for the purpose of seed production, usually from trees of improved and specific genetic quality.

Seed processing (seed processing and handling)

The processes conducted after seed collection to prepare seed for use or storage, including: sorting, extraction, cleaning, grading, drying, storage, and transportation.

Seed production area

A stand of trees in either a natural forest or plantation that is managed for the specific purpose of seed production. Stand improvement is conducted by selective thinning to remove poorer quality trees and retain trees of superior quality at optimal spacing for seed production.

Seed source

An individual tree or stand of trees, natural or planted, from which seed is collected.

Seed stand

A group of trees identified in a natural forest or plantation that have superior characteristics, such as straight stem or fast growth, and are managed as a seed source.

Seed supplier

An individual, group or company that provides commercial quantities of seed. Seed may be produced/collected to fill orders and/or maintained in stock. Seed suppliers usually supply seed of certain species, varying from one to many.

Seedling

A plant regenerated from any form of germplasm.

Stump

A section of stem or root used to produce a new plant through vegetative propagation methods.

Vegetative propagation

1) The production of new plants directly from vegetative material, usually stems, roots, or leaves. 2) The production of plants from material other than seed.

Wildling (wild seedling)

A seedling, originating from natural regeneration, that is collected from a forest, plantation, garden, or agricultural land for replanting elsewhere.

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Tree nurseries are a key success factor in many forestry and agriculture development interventions.

Over the last two decades, the World Agroforestry Centre (ICRAF), Winrock International, and University of Philippines Los Baños (UPLB) have worked with hundreds of small-scale and large-scale tree nurseries across Southeast Asia. Most of those nurseries were located in Indonesia and the Philippines. The purpose of the nurseries has varied from commercial biomass production, to land rehabilitation and forest conservation, to local capacity building and livelihood enhancement.

Partners involved with operating those nurseries have included farmers, entrepreneurs, commercial firms, non-government organizations (NGOs), communities, projects, and government agencies.

This sourcebook was written to share the learning and insights from those experiences with a broader audience. It is not a technical manual. Rather the sourcebook provides interested individuals and organizations with sufficient information and general principles regarding the identification and development of the right type of nursery for their conditions. Readers are welcomed to use and share the sourcebook freely and encouraged to contact the authors with comments and inputs regarding the sourcebook or tree nurseries in general.



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