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Choosing Best Practice Nursery: A Way Forward for a Successful Plantation Project



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Our Cover

A typical household managed individual nursery at Kalapani CFUG, Bethanchok Rural Municipality of Kavrepalanchowk district. By Prem Bahadur Shrestha- Nursery Operator and Chairperson of Kalapani CFUG.

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Choosing best practice nursery: A way forward for a successful plantation project

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ACRONYMS

AF	Agroforestry
CFUG	Community Forestry User Group
DFO	Divisional Forest Office
DOFSC	Department of Forests and Soil Conservation
EnLiFT2	Enhancing Livelihoods from Improved Forest Management in Nepal
FECOFUN	Federation of Community Forestry Users Nepal
FGDs	Focus Group Discussions
FRTC	Forest Research and Training Center
INGOs	International Non-Government Organizations
LG	Local Government
MOFE	Ministry of Forest and Environment
NAF	Nepal Agroforestry Foundation
NAFSCOL	Nepal Agroforestry Seed Cooperative Limited
NGO	Non-Government Organization
NTFPs	Non-timber Forest Products
POMITFE	Provincial Ministry of Industry, Tourism, Forests and Environment
TISC	Tree Improvement Silvicultural Component
RM	Rural Municipality
TOT	Training of Trainers
UUL	Under Utilized Land

SUMMARY

In view of the existing drawback of nursery seedling production and distribution system in Nepal, this paper provides some important notes for selection of best practice nurseries. In this paper, five nursery types including the Divisional Forest Office (DFO) managed nurseries, local government supported nurseries and community forest user group (CFUG) managed nurseries, and registered commercial private nurseries and individual (home) nurseries are discussed. All nursery types are important interlinked components of national seedling supply systems and reforestation and also for private tree planting programs. For this study, data collection methods involved case study of eight nurseries using a standard checklist questionnaire, nursery records, field observation and focus group discussions (FGDs). These data were complemented by secondary sources of information including EnLiFT2 (Enhancing Livelihoods from Improved Forest Management in Nepal) consultant's report and other literature. Review results show that tree seedling production capacity in Nepal is very high. In the last four decades (1978 to 2018), a total of 1.37 billion seedlings were produced in the entire country. If these seedlings were planted at a spacing of 5x5 m distance, it would have covered more than 3.4 million hectares (ha) of land which is more than half of the forest land of Nepal. What has happened to these plantations? Beside this production, there are many other institutions and projects that are also producing tree seedlings. EnLiFT2 project for example is involved in production of various species of tree seedlings, which would account to more than 2, 00,000 (2 lakhs) annually.

The success of tree planting depends on the quality of seedling used. Except commercial private tree nursery growers, government and community managed nurseries do not meet the quality of seedlings. The DFO managed nurseries have somehow adequate human resource and equipment for the management of planting stocks such as seed beds, transplant beds and hardening beds. Watering systems and shade are maintained. However, the local government supported and CFUG managed and individual nurseries have less infrastructure facility. Mainly Individual (home) nurseries have inadequate infrastructure, fencing and low levels of inputs such as polythene bags, water cane, and polythene sheet for green house among other. In terms of commercial orientation, private nurseries are profit-oriented and the case with individual nurseries that are also private but not registered with the government as private company. Private nurseries have appointed outside skilled and non-skilled workers in their nurseries and earning a handsome amount of profit margin unlike other nurseries. The DFO managed nurseries do not sell their seedlings. However, they are relatively better place for training of community members and individuals. Because of individual commitment and skilled and experienced operator, private nurseries are also considered as good training platforms for basic and advanced nursery propagation techniques. This is with the fact that EnLiFT2 project used private nursery operators as resource persons in the Training of Trainers (TOT) held in DFO managed nurseries at Patlepani, Sindhupalchowk. In terms of extension and other management services, DFO managed nurseries are relatively better training venues. 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 external/internal support services. Therefore an integrated approach needs to be followed before opting for the operation of the nurseries. This suggests that DFO managed nurseries are better for technology development and innovation, and producing fast growing timber and fuelwood tree seedlings. While local government managed nurseries are excellent sources for communicating with local nurseries and farmers. Local government supported nurseries can distribute seedlings within their territories if they have it in excess, while they can also bring it to sub-divisional forest offices for distribution. The CFUG and individual nurseries are better sources for implementing a small community and private plantations locally. Commercial private nurseries are excellent source for communicating external technology to be linked to government, particularly to DFO nurseries. High value tree seedlings are the sources for Private nurseries that can have better link to market for all nurseries.

INTRODUCTION

Background

Tree nurseries played an important role for the success of many forestry and agriculture development programs. The history of forest nursery in Nepal dates back to 1965 with defined objectives (Lamsal 2020). Over the last five to six years, the EnLiFT (Enhancing Livelihoods and Food Security from Agroforestry and Community Forestry in Nepal) project in collaboration with the Ministry of Forests and Environment (MOFE) had worked with a few small-scale home nurseries and medium size tree nurseries across its project districts (Kavrepalanchowk and Lamjung) during the first five years (2013 to 2018). With the inception of second phase of the project (known as Enhancing Livelihoods and Food Security from Improved Forest Management in Nepal or EnLiFT2) in 2019, Sindhupalchowk district is included. Almost 100 small scale home nurseries produced a minimum of 100 to a maximum of 500 seedlings per nursery. While medium size nurseries produced at least 20,000 seedlings per nursery each in six project sites. However production capacities varied ranging from 10,000 to 30,000 based on sites and demand of local communities. The purpose of nurseries includes commercial seedling production, to land rehabilitation and forest conservation, to local capacity building and livelihood enhancement (Roshetko *et al.* 2010; Pandit *et al.* 2018). These nurseries are operated by farmers, entrepreneurs, commercial firms, nongovernmental organizations (NGOs), communities, and government agencies. The focus of EnLiFT project was particularly on farmers' home nurseries, which was later converted to medium sized seedling production nurseries. This project worked with the six medium sized nursery operators with varying size, composition, and length of the nursery growing period. Likewise, individual and home-run nurseries produced around 500 to several thousand seedlings per season (Pandit *et al.* 2018). Large commercial or government nurseries produced at least 50,000 to 100,000 seedlings per season. On average, group or community nurseries produced 5,000 to 15,000 seedlings per season (field report EnLiFT 2, 2020).

While working on these nurseries in the past, we observed several constraints in order to promote nursery and plantation at local level. The most important constraining factor for the current approach (distributing seedlings free of costs) is somehow problematic in terms of recovering costs. The statement from Lamsal (2020) illustrates difficulties in nursery management.

'Due to various institutional, technical and procedural factors, the quality of government nurseries has been reduced drastically and all practices are proven less effective. Despite of a long practice, nursery management still suffers from various institutional deficiencies like weak commitment, skilled manpower, and consultation from policy to implementation, unclear budgetary arrangements and existing procurement system. Seedling quality, choice of species, gap between demand and supply had made private nurseries a better alternative to government managed nurseries in the recent years.'

The free distribution system of government managed nurseries (DFO and local government managed) is not sustainable and there's always a certain level of dependency. Because of this, farmers may not be willing to buy seedlings from private nurseries. On the other hand, the seedlings available in government nursery are mostly timber, fuelwood, fodder and a few Non-timber Forest Product (NTFP) species. While the farmers usually prefer fruit trees and grasses, hundreds of timber and fuelwood species seedlings are being stocked in many government nurseries.

The Government of Nepal unveiled an ambitious plan on planting 50 million seedlings in the fiscal year 2019/20 (Mandal 2019). Using maximum standard spacing of 5x5 m (approx. 25 m²), this target requires at least 2 million ha of land, which is almost one-third of Nepal's total forest land area (6.6 m ha). As a plantation drive, these seedlings will also be planted outside the forest area (including underutilized private land). Therefore, extensive nursery facilities will be needed to achieve the staggering seedling demand and land rehabilitation. Furthermore, area in need for rehabilitation of under-utilized lands exists across Nepal, mainly in remote areas of hills and mountains (Paudel *et al.* 2014; Ojha *et al.* 2017). Experience indicates that most districts of Nepal 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 (Pandit 2019). Governments need to support private sector for producing high quality seedlings in order to achieve improvement of people's livelihoods and land rehabilitation targets.

This paper would be useful for policymakers and local governments, project designers and program implementers, government land survey department and extension staff, NGO managers and field staff, farmer leaders and farmer groups. This is intended for any organization or individual interested in tree nurseries, reforestation or tree planting activities. This is intended to provide readers with fresh information, examples and general principles to identify and develop the right type of nurseries in their areas. The specific objectives of this paper are highlighted below.

Objectives

- To identify seedling production modalities of different types of nurseries.
- To investigate innovations on nursery administration and management of different types of nurseries.
- To recommend and present ways forward for the management of planting stock production system, cost effectiveness and ensuring superior germplasm sources.

METHODOLOGY AND CASE STUDY (NURSERY) SITE SELECTION

Data collection

Both primary and secondary sources were adopted for the data collection. Primary information was obtained from survey of eight nurseries located in eight sites, four each of the two project districts, Sindhupalchowk and Kavrepalanchowk districts (Figure 1). For detailed case study of the nurseries, a questionnaire was developed as a guideline for discussion. This questionnaire was developed through an interactive process of discussion and communication (e-based) between senior project leaders, DFOs and volunteers. This survey included information about size of the nursery, which species were prioritized to raise seedlings, rice range of the seedlings, scale of commercialization, seedling quality standard, germplasm source, type of technologies used, management structure, research and innovation, training capacity building, extension services and best practices of the nurseries.

These eight nurseries were purposively selected because the project provided training to them on 23-26 February 2020. Of the eight nurseries, two are managed by the DFOs, two are managed by private commercial firms, two were managed individually, and one by a CFUG while the other one involved the local government-supported nursery. The rest of primary information was complemented through each of the nursery records, field observation and focus group discussions (FGDs) with respective nursery operators. The secondary data included mainly from literature review and DFO and Department of Forest and Soil Conservation (DOFSC) including consultant's report.

Location of selected nursery types

Out of the eight nurseries selected for this study, four nurseries are located each in Sindhupalchowk and Kavrepalanchowk districts (Figure 1). These nurseries are divided into five types based on its objectives and functions. In Sindhupalchowk district for instance, DFO managed nursery is located at Patlepani of Chautara-Sanghachok-6, CFUG nursery is located at Deupokhare- Thulo-dhading of Lisankhupakhar-1, individual (home) nursery at Daduwa of Chautara Sangachok-14 and private commercial nursery at Badhare of Indrabati-10. This district however does not have local government managed nursery. While in Kavrepalanchowk, DFO managed nursery is located at Budol of Banepa-1, local government managed nursery is located at Chaubas Bhumlu-4, individual (home) nursery at Kalapani Bethanchowk-4, and private commercial nursery is located at Khahare Bethanchok-2 (Table 1).

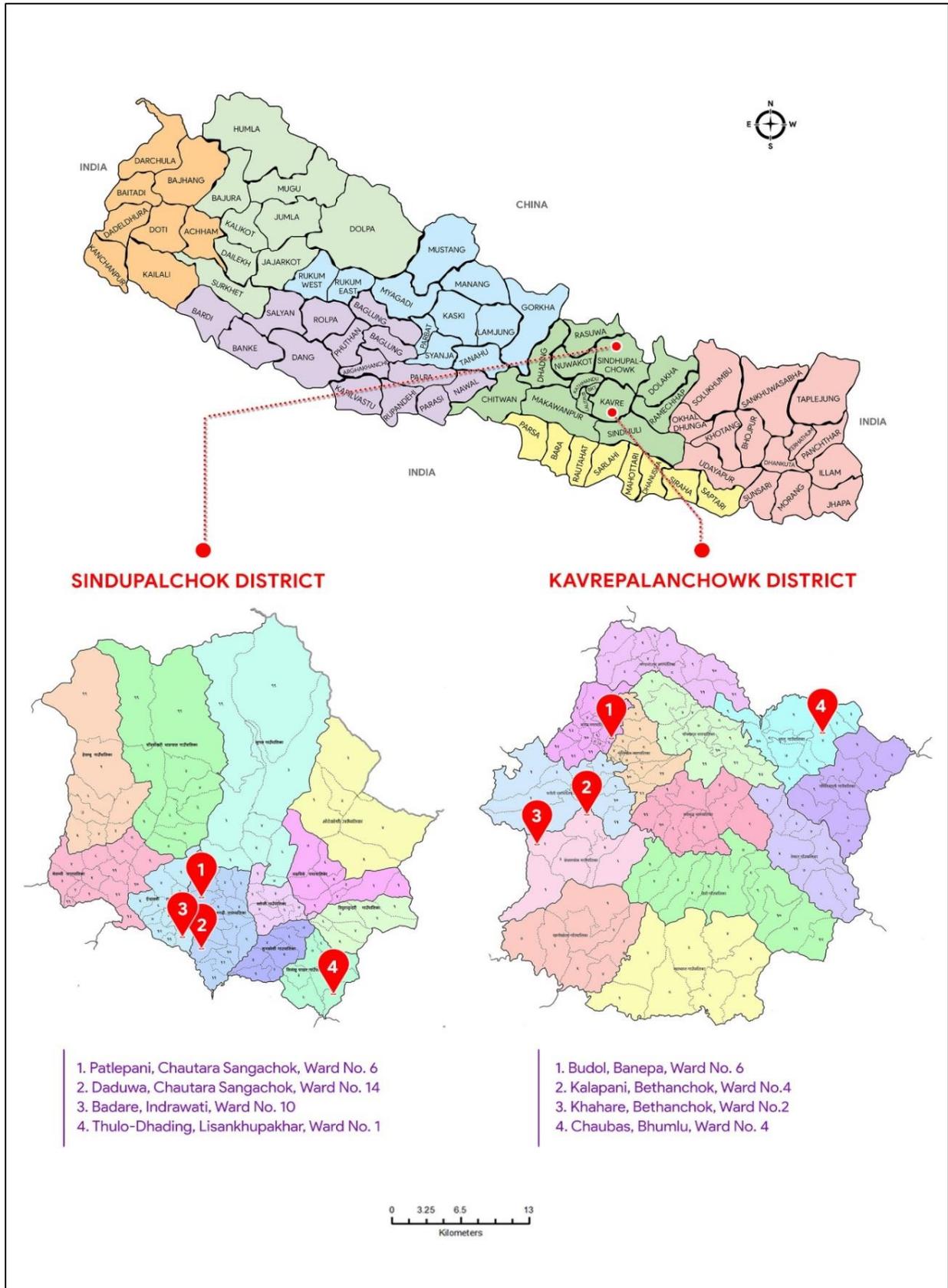


Figure 1 Location map of eight supported nurseries in Sindhupalchok and Kavrepalanchowk districts

Table 1: Description of selected nurseries for the case study

Nursery site name	Nursery type or management	Address	Gender and ethnicity of the nursery operator
Budol nursery	DFO	Banepa Municipality-1, Kavrepalanchowk	Female and Gurung
Daduwa nursery	Individual	Chautara Sangachowk-14, Sindhupalchowk	Female and Dalit
Chaubas nursery	Local government	Chaubas Bhumlu-4, Kavrepalanchowk	Male and Dalit
Kalapani Dhungkharka	Individual	Bethanchok-4, Kavrepalanchowk	Male and Newar
Patlepani	DFO	Chautara Sangachok-6, Sindhupalchowk	Both female (Brahmin) and male (Newar)
Deupokhari	CFUG	Lisankhupakhar-1, Thulodhading, Sindhupalchowk	Male and Tamang
Khahare agriculture and herbal seedling production Pvt. Ltd	Private Commercial	Bethanchok-2, Kavrealanchowk	Male and Brahmin
Badare Agroforestry nursery Pvt. Ltd	Private Commercial	Indrabati-10, Sindhupalchowk	Male and Brahmin

Similarly in Kavrepalanchowk district, there is no CFUG managed nursery within the project site. 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 (Roshetko *et al.* 2010; Gregorio *et al.* 2010; Farooq *et al.* 2017).

General characteristics of the nurseries

DFO managed nurseries

Two nurseries (one in each district) have been established and operated by the Divisional Forest Offices, for more than three decades to support reforestation and community tree plantation programs. The scale of operation is generally large in these nurseries, with production capacities directed by government targets. For instance, during the year 2019/20, more than 50,000 seedlings of different tree species were produced in these nurseries. Other government units (the Nepal Army and local governments), Universities (Kathmandu University) and civil societies and communities also collaborated with these nurseries to provide seedlings to meet national or local needs (Personal communication with Assistant Divisional Forest Officer of Kavrepalanchowk). In recent years, government decentralization in Nepal has resulted in the devolution of tree nurseries for local management. These nurseries have less intensive nursery seedling cultivation operations and low manpower than private commercial nurseries. In general,

limited emphasis is placed on the quality of seedlings produced in these nurseries. The seedling production process is not market-driven but rather governed more by requests from government organizations or local governments. The Provincial Ministry of Industry, Tourism, Forests and Environment (POMITFE) have more influence on the DFOs for the management of these nurseries.



Photo 1 Patlepani and Budol DFO managed nursery (Photo credit by Tula Ram Ghimire- left and Ram Kumar Bhandary- right)

Local Government managed nurseries

This type of nursery is being supported by Chaubas-Bhumlu Rural Municipality of Kavrepalanchowk district. This was established in 2019, a year after the TOT on nursery management was organized at Patlepani nursery in Sindhupalchowk district. At least 30,000 seedlings of more than 15 species are grown in this nursery. However, these are relatively smaller than the DFO managed nurseries. The choice of species was based on the demand of local communities. Before 2008 when a Federal Republic of Nepal was declared, nurseries were managed by the Panchayat¹. With this new system of governance, local government officials and the Mayors started to take on nursery operation as one of the key services.

¹ Panchayat was the political system of Nepal from 1960 to 1990. It was based on the Panchayat system of self-governance historically prevalent in Nepal where local bodies would function. This was the system of government in which there was party less system.



Photo 2 Chaubas Local Government managed nursery (Photo credit by Netra Bahadur Kunwar)

CFUG managed nurseries

CFUG managed-nurseries are established to build technical and leadership capacities of group members and expand the number of species and quality of germplasm available to their group members. This type of nurseries used to prevail during 1990s until 2000, but almost disappeared in the last one and half decades in both Kavrepalanchowk and Sindhupalchowk districts. However, with advent of the democratic system, this type of nurseries is slowly reviving. Deupokhari CFUG started this type of nursery in late 2019 and continues to operate with support from the EnLiFT2 project and the Community Forest User Group members. Currently DeuPokhari nursery has 12,120 seedlings. Nursery sizes may vary depending on their location. Roshetko et al. (2010) reported that small group of nurseries may be operated by as few as two to three 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 of nurseries tend to stop operating when objectives are met or external support is terminated.



Photo 3 Deupokhari CFUG managed nursery (Photo credit by Bishnu Hari Pandit)

Individual (Home) nurseries

Individual nurseries are generally established and managed by individual farmers and/or their families. These nurseries are not registered with the government and run by family members. These nurseries are usually initiated to produce seedlings for planting on operators' personal farms and in some cases in neighboring community members' farms. With individual interest, project supported two individual home nurseries, one each in Sindhupalchowk and Kavrepalanchowk districts. One is being run by female nursery operator (Ms. Sunita Ramtel) who is from a disadvantaged group, while the other is being operated by a male member. The house compound and farmland in the community have been used as the planting sites. These nurseries may distribute seedlings within the community and occasionally cater to the needs of small-scale tree planting projects. The nursery size is relatively smaller (3000 to 5000 and sometimes up to 15,000 with the exception of Kalapani nursery) only to meet the need of the household and project demand. Mr. Prem Prasad Shrestha of Kalapani of Kavrepalanchowk district has produced more than 10,000 seedlings of at least 10 species that are locally threatened and endangered. Despite of limited size, these nurseries produce more variety of species.



Photo 4 Individual household managed nursery (Photo credit by Prem Prasad Shrestha-left and Bhesh Bahadur Khatri-right)

Registered private commercial nurseries

These types of nurseries are registered either as a private company or a Cooperative and are generally profit-oriented. They are commonly established and operated by any individuals who want to run the nursery as a business firm. Two nurseries, one each in Sindhupalchowk and Kavrepalanchowk district are being operated by two registered companies (Agroforestry nursery Private Ltd. Badare, Indrabati-10 and Khahare Agricultural and herbal Multipurpose nursery Private Ltd). These nurseries generally have high production capacities and generate high volumes of seedlings annually. Agroforestry nursery produced at least 50,000 seedlings of various tree species. Almost half of this production was for fodder tree seedling contracted by the District Agricultural Knowledge Center and other half belonged to high value tree species (Fruit and NTFPs) such as lime, lemon, banana, grafted mango, Paulownia, *Terminalia*, *Emblica officinalis*, wall nut, Sandle wood, Macadamia nut and bamboo. This nursery has five to six regular skilled workers in the farm. Seedling sale outlets are established in Kathmandu. Agricultural and herbal company also produced mostly high-valued tree based NTFP species such as *Taxus baccata*, Walnut, *Pyrus polyphylla* (Satuwa), *Prunus cerasoids*, *Morus alba*, *Citrus lemon* (see Table 5). Seedling production complies with the size (height and vigor) of the plant. 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. These nurseries can provide quality seedlings to communities of smallholder farmers including private tree farmers who want to serve as out-growers for large scale plantations.



Photo 5 Private commercial nurseries (Photo credit by Ram Prasad Gautam- left and Krishna Prasad Timilsina-right)

RESULTS AND DISCUSSIONS

Genetic resources (seed and seedlings) and production

Conservation is the management of genetic resources so that they can provide the greatest sustainable yield to benefit the present generations while preserving their potential to meet the needs and aspirations of future generations (Tamrakar 2003). Long term and sustainable production of seedling depends on quality and source of germplasm. These are living genetic resources such as seeds or tissues that are maintained for the purpose of plant propagation, preservation, and other research uses. These resources may take the form of seed collections stored in seed banks and trees growing in nurseries. Therefore, it is important to work on conservation of genetic resources. A practical way to preserve the valuable tree species is not only to conserve but also to utilize at the same time. It is necessary to estimate the present status of tree species and to develop and implement a conservation and utilization program. This would assist in supplying the needed forest products, help in carrying out management of the environment and improve the economic conditions of the local people. Tree Improvement Program (TIP) in Nepal is playing the role of conservation of genetic resources by providing seeds of various tree species. The Forest Research and Training Center (FRTC) and Tree Improvement Silvicultural Component (TISC) are jointly mandated to supply seed required for plantation activities in the country. TISC carries out identification, registration and management of natural seed stands of important tree species, and establishment of breeding seed orchards from where seed or any planting material is secured. The breeding seed orchards have been established in different parts of the country.

The main germplasm source of forest tree species is TISC for the DFO managed nurseries. However, they procure seeds of commercial fruit and improved exotic fodder tree species (such as *Leucaena*, *Flemingia*, *Teprosia*) from private seed companies based in Kathmandu. Nepal Agroforestry Seed Cooperative Limited (NAFSCOL) is the main seed supplying agency to many government and non-government projects in the central region of Nepal including project sites. Likewise, the local government managed nurseries depend mainly on DFOs for their seed source and obtain some seeds from local seed cooperatives and private companies. CFUGs and individual nurseries collect seeds of timber and fuelwood species from their community forests. Similar to DFO managed nurseries, CFUG, private and individual nurseries procure fruit trees, NTFPs and fodder tree seeds from private seed companies. The species propagated in individual nurseries are selected exclusively by operators but 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. Private companies on the other hand have contract with the local seed producer farmers in several locations of the country. Overall, it can be said that there is no authentic sources of germplasm in Nepal.

Nursery seedling production and distribution

Seedling production at country level

The records on seedling distribution from TISC alone during 1992 to 1998 shows that around 88 million seedlings were distributed (Tamrakar 2003). Overall Nepal's seedling production was 1.3 billion in the last 40 years period (1978 to 2018) (Table 2). Besides this, a number of NGOs, civil society organizations, cooperatives, companies and groups have also been involved in plantation campaign by producing their own seedlings.

Table 2: Seedling distribution

Year of distribution		Total seedlings
1978-1998	1999-2019	
663 million	707 million	1.37 billion (avg 34.2 million)

Source: Compiled from Lamsal et al. 2020

The forest and agriculture land accounts for more than half (8.5 million ha) of the total country's land area. Using standard initial tree planting distance (5m x 5m = 25 m²), Nepal would have covered it's almost half of the whole forest and agricultural land areas with the seedlings produced.

Nursery seedling production at project site

EnLiFT2 project has adopted different seedling production models and support systems. Table 3 shows seedling production of eight nurseries this year. The DFO managed nurseries are located near to the district headquarters, one each in Sindhupalchowk and Kavrepalanchowk district. There is only one nursery each managed by the CFUG and the local government. As discussed earlier, private commercial nurseries are also two, one each district. Currently, a total of 256, 208 seedlings are being grown in these eight nurseries (Table 3). The largest nursery is being managed by the DFO at Patlepani followed by Private commercial nurseries at Badare of Indrabati Rural Municipality-10. Local government managed nursery at Chaubas stood third in terms of seedling production. During the EnLiFT1 project period, more than 100 families of three communities of Lamjung district were supported with more than hundred thousand of seedlings of mixed species. The farmers of two sites are continuing seedling production and earning at least NRs 50,000 per year from the sale of seedlings to their neighboring farms and families (Pandit 2019).

Table 3: Seedling production at project site

Nursery sites	Nursery type	Quantity of seedlings	Main Seedling species
1. Budol nursery, Kavrepalanchowk	DFO nursery	19,413	<i>Juglans regia</i> , <i>Melia azedarch</i> , <i>Choerospondias axillaris</i> , <i>Sapindus makorossi</i> , <i>Phyllanthus emblica</i> , <i>Paulownia tomentosa</i> , <i>Pinus patula</i> , <i>Black juniper</i> , <i>Callistemon</i>
2. Daduwa Sindhupalchowk	Individual nursery	4,536	<i>Paulownia tomentosa</i> , <i>Juglans regia</i> , <i>Flemingia congesta</i> , <i>Melia azedarch</i> , <i>Phyllanthus emblica</i> , <i>Leucaena leucocephala</i> , <i>Citrus limon</i> , <i>Zanthoxylum armatum</i>
3. Chaubas Kavrepalanchowk	Local government	32,123	<i>Juglans regia</i> , <i>Flemingia congesta</i> , <i>Melia azedarch</i> , <i>Phyllanthus emblica</i> , <i>Leucaena leucocephala</i> , <i>Zanthoxylum armatum</i> , <i>Taxus baccata</i> , <i>Paulownia tomentosa</i> , <i>Citrus limon</i> , <i>Eucalyptus camaldlensis</i>
4. Kalapani, Dhungharka, Kavrepalanchowk	Individual nursery	13,127	<i>Zanthoxylum armatum</i> , <i>Juglans regia</i> , <i>Flemingia congesta</i> , <i>Melia azedarch</i> , <i>Embllica officinalis</i> , <i>Leucaena leucocephala</i> , <i>Citrus limon</i> , <i>Alnus nepalensis</i>
5. Patlepani, Sindhupalchowk	DFO nursery	83,928	<i>Taxus baccata</i> , <i>Edgeworthia gardeneri</i> , <i>Bauhinia variegata</i> , <i>Pinus patula</i> , <i>Juglans regia</i> , <i>Melia azedarch</i> , <i>Phyllanthus emblica</i> , <i>Leucaena leucocephala</i> , <i>Citrus limon</i> , <i>Sapindus makorossi</i> , <i>Choerospondias axillaris</i>
6. Deupokhari Sindhupalanchowk	CFUG	12,120	<i>Zanthoxylum armatum</i> , <i>Camelia chinensis</i> , <i>Paris polyphylla</i> , <i>Juglans regia</i> , <i>Flemingia congesta</i> , <i>Melia azedarch</i> , <i>Phyllanthus emblica</i> , <i>Leucaena leucocephala</i> , <i>Citrus limon</i>
7. Khahare, Dhungharka, Kavrepalanchowk	Private Commercial	13,571	<i>Saurauia napaulensis</i> , <i>Taxus baccata</i> , <i>Valeriana wallichii</i> , <i>Paris polyphylla</i> , <i>Citrus sinensis</i> , <i>Juglans regia</i> , <i>Flemingia congesta</i> , <i>Melia azedarch</i> , <i>Phyllanthus emblica</i> , <i>Leucaena leucocephala</i> , <i>Citrus limon</i> , <i>Alnus nepalensis</i>
8. Badare, Sindhupalchowk	Private Commercial	77,391	<i>Delonix regia</i> , <i>Phyllanthus emblica</i> , <i>Flemingia congesta</i> , <i>Bauhinia purpurea</i> , <i>Ficus semicordata</i> , <i>Ficus auriculate</i> , <i>Citrus limon</i> , <i>Prunus cerasoides</i> , <i>Leucaena leucocephala</i> , <i>Juglans regia</i>
Total		256,208	

Source: Telephone interview with nursery care takers, 2020 (May 7 2020)

Qualities, Technologies and Commercialization of seedlings

Qualities and quantities of seedlings

The success of tree farming is greatly influenced by the quality of seedlings used. Seedlings coming from a nursery should be of high quality such as acceptable structure, good looking appearance, height of seedling (> 25 cm), and quality of stem (straight and vertical), branches, leaves (natural green) and roots (well firmed), and therefore, the nursery operator should focus on raising high quality seedlings rather than on the number of seedlings produced. Higher quality seedlings have numerous advantages including low mortality rate, low plantation maintenance costs, shorter rotation period and high timber quality (Gregorio *et al.* 2010). Most government nurseries in Nepal 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 (Roshetko *et al.* 2010). The best available germplasm is used to support these activities. However, in Nepal, because of so many limitations (see Table 4), these nurseries are not producing quality seedlings. Robinson and Thompson (1989) claimed that failure in plantation is caused by several reasons including small size of seedlings, poor growth, poor quality, and negligence in planting, no weeding and other intercultural operations. Historically, DFO managed nurseries have focused on a limited number of timber species. Recent trends show an inclination towards producing seedlings of varied tree species including fruit trees and NTFPs. While there are efforts in DFO nurseries to use high quality germplasm, private nurseries relatively employ better practices. In government nurseries, seedling quality standards are also inferior compared to other nurseries. The usual practice is to focus on seedling quantity, rather than quality (Lamsal 2020).

Private nurseries view seedling quality as an important indicator of a successful plantation project (see Table 4). Strong quality control means ensuring higher seedling survival and excellent growth after plantation. Private nurseries also attempt to increase the quality of production inputs. They have access to reliable seed sources and facilities for proper seed processing, handling and testing. Private nurseries also produce large quantities of seedlings and at the same time, they are focusing more on sale and market.

CFUG nurseries on the other hand determine the species of seedlings produced, with inputs from the target community and members within the group. Initially, these 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, non-timber, fruit and multi-purpose trees may fall in the list of priority species, while the quantity of seedling production varies from 5,000 to 12,000. Timber based NTFP has become the priority of Deupokhari CFUG nursery. These nurseries usually produce good quality seedlings. They often have access to, and the ability to secure germplasm locally. Germplasm is generally collected from local seed sources to encourage community participation and income generation. All Timur cuttings were collected locally by CFUG members and paid for their work (daily wage). To establish credibility, high quality genetic materials such as seeds collected from reliable source, clean (no foreign material) and well extracted and dried may be used in these nurseries, particularly those supported by EnLiFT2 in Deupokhari, Sindhupalchowk. CFUG members aim to produce high quality seedlings, especially if these will be planted on their own farms. Support institutions are also involved with input and facilitation. The quality of local seed can be guaranteed and enhanced by following appropriate seed collection guidelines.

Table 4: Strength, weakness, opportunity and threat (SWOT) analysis

Nursery types	Strengths	Weakness	Opportunity	Threats
DFO managed nurseries	Rely more on natural ecological process Covering whole area Free distribution Tree seedlings are readily available from these nurseries Meeting quality standard Training	Delayed in release of funds Mismatched with community choices Management limited to seasonal basis Lack of quality	Funds assured from the government Women employment Needs to focus on farm tree growing High potential to expand the number of species	Target oriented Change in political preferences Curtailling of species selection and distribution Conflict with local government
Local govt managed nurseries	Locally governed Covering whole Palika area Free distribution Awareness at local level Transparent	Lack of technical knowledge Mgt. depends on the choice of ward chair Lack of quality	Women and poor people employment Opportunity for fruit tree growing Greening of villages	More rely on outside technician Covering only its Palika pocket Political influence in distribution
CFUG managed nurseries	Community involvement Poorer family employment Free distribution Seedlings produced on community needs Increased adaptive capacity	Limited technical person Community may not be willing to provide its funds as salary of Nursery care takers Lack of quality	More greening the community Community empowerment Scope for collaboration with Local Government Community inputs Awareness	Community disputes on priority Competition between nurseries of private holders Political influence in distribution
Individual home nurseries	Self-supporting Local expertize developed Seedling sale generates family income Seedlings produced on demand	Financial constrains Sometime dependent on government for resources Mgt. limited to individual farmer	Employment at own farm More focus on income generation Scope for quality seedling production	Competition between nurseries Climate change disaster (dry and drought) Supply of inputs
Registered private nurseries (commercial)	Cost effective Commercially oriented More and more cash generating seedling are raised Sustainable Quality standard maintained	Mgt. limited to private entrepreneur Lack of transparency Less or no social motive	Scope for collaboration with government and community nurseries Business orientation Opportunities for growing fruit seedlings	Competition between nurseries Threat of extinction of threatened species (Kharsu) Natural disaster

Source: Compiled from various sources including case studies of nurseries- 2020

Annual seedling production is commonly 1000 to 10,000 but may be as little as 50 or less. In commercially-oriented individual nurseries (Private registered), annual production capacity is as high as 77,000 (Table 3). As commercial enterprises with reputations to maintain, these nurseries are more likely to use quality seed sources.

Technology and research

Some of government managed nurseries, such as DFO Patlepani, Sindhupalchowk and Budol, Kavrepalanchowk nurseries have staff for monitoring and other facilities such as storage house and shade houses for keeping planting stocks. Cutting of five species such as *Zanthoxylum armatum* (timur), *Juglans regia* (walnut), *Taxus baccata* (Loathsalla), *Morus alba* (Kimbu), *Edgeworthia gardneri* (Argeli) were tried using root hormones. Similarly, another 26 species trial was done on direct seeding on the raised beds (Annex 2). The performance of the 31 species including five species cutting is being assessed by the nursery operators. Concepts of hardening beds, germination beds and transplant beds were also provided during the training. A more accurate assessment of seedling performance is made timely. Depending on the available budget there may be a simple area where the minimum facilities (seed beds, watering system, and shades) of a nursery are present. In other cases, where project support is lacking, these 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.

Private registered nurseries have easy access to and use the most current or appropriate technologies such as seed germination method, filling polythene bags, green net cover etc. They develop species-specific protocols for cost effective seedling production. The process of technological development, refinement and adoption occurs more rapidly in these nurseries than other nursery types, except for DFO nurseries. In most cases, private nurseries can serve to showcase technology and researches.

The level and types of technologies (simple-seedlings are grown in natural environment; medium-plastic and green net used and high- iron structure and sprinkle water used) employed in local government managed nurseries is less advanced than that used by private and DFO managed nurseries, and also they are less advanced in CFUG and individual nurseries. This enables local government managed nurseries to efficiently produce quality seedlings and provide a learning environment for community members.

A mixture of indigenous and adapted technologies (instead of plastic green house, thatch roof houses are used for germination shed, instead of iron hardening bed, bamboo frame was used) is employed in group nurseries (developed by DFO or local government nurseries). But nurseries with external support tend to use more adopted technologies such as high tech nursery with sprinkle water facilities). Due to limited resources however, many CFUG nurseries develop cost-effective, small-scale technical innovations.

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. Available materials, such as plastic bags, are commonly recycled.

Commercialization

Two government nurseries (DFO and local government managed) are not market-oriented although there were some instances of seedlings sold to the public at a nominal price. In order to sustain production, government nurseries are increasingly moving towards commercialization as seen in other parts of the country (Pandit 2019). However, seedlings are often sold in small,

limited quantities, unlike private commercial nurseries where seedlings are sold in bulk. Unlike government nurseries, most private nurseries are centered on selling the seedlings. They are commercial in size and scale of production. Seedling production is meant to satisfy the seedling requirements of individual or companies who buy the seedlings. They produce seedlings in bulk for commercial sales supply to large purchasers (Table 5), but also fill small purchase requirements, which are not recorded here. Small purchase requirements are mostly fulfilled by individual nurseries.

Table 5: Seedling sale from Private commercial nurseries in bulk during 2018/19

Species name	Agroforestry Nursery Pvt. Ltd. Badare			Khahare Agri and Herbal Multipurpose nursery Ltd.		
	No	Rate Rs	Total amount Rs	No	Rate	Total amount Rs
<i>Ficus nemoralis wall.</i> (nimaro)	1800	35	63000			
<i>Ficus semicordata Buch. Ex.J.E. Smith</i> (Rai-khaniyo)	1700	40	68000			
<i>Bauhinia Purpurea L.</i> (tanki)	3100	25	77500			
<i>Melia azedarach L.</i> (bakainu)	4000	20	80000			
<i>Morus alba Mora.</i> (kimbu)	13000	8	104000	3500	5	17500
<i>Terminalia chebula Retz.</i> (harro)	700	25	17500			
<i>Terminalia ballerica (Gaertn.) Roxb.</i> (barro)	600	25	15000			
<i>Sapindus mukorosi Gaertn.</i> (ritho)	400	20	8000	400	10	4000
<i>Dendrocalamus strictus Roxb.</i> (Bamboo)	15000	50	750000			
<i>Paulownia tomentosa Franz.</i>	2500	50	125000			
<i>Citrus lemon Burm.</i>	600	40	24000			
<i>Citrus aurantifolia Barret.</i> (lime)	4000	50	200000			
<i>Texus baccata L. Hulme</i> (loathsalla)				2800	35	98000
<i>Juniperus indica Bertol.</i> (Dhupi)				400	25	10000
<i>Paris polyphylla Sm.</i> (satuwa)				50	40	2000
<i>Prunus cerasoids D. Don.</i> (painu)				1500	9	13500
<i>Salix alba S. fragillis</i> (salix)				1500	9	13500
Total	47400		1,532,000	10150		158,500

Source: Records provided by respective nursery entrepreneurs- May 2020

Although established to meet family needs, individual nurseries also sell seedlings in local markets. Individual nursery at Kalapani, Dhungharka is being evolved towards market-orientation. Some individual nurseries become exclusively commercial enterprises and provide significant income to owner-operator (Roshetko *et al.* 2010). Khahare private nursery is an example where there is a strong market demand for tree seedlings. Some researches revealed that majority of farmers were practicing Agroforestry for economic benefits (Cedamon *et al.* 2017; Farooq *et al.* 2017), while most of the farmers were growing some fodder (*Artocarpus*, *Morus alba*) and timber species -*Eucalyptus camaldulensis* (Sufaida) and *Dalbergia sissoo* (Shisham) on their farmlands. Most private nurseries grow seedlings that are suitable for planting in

agroforestry system. The most commonly grown tree species in coffee plantations were *Ficus natalensis*, *Artocarpus heterophyllus*, *Maesopsis eminii*, *Mangifera indica*, *Persea americana* and *Albizia chinensis* in Uganda (Kalanzi and Nansereko 2014). Networks of individual nurseries may form to respond to such market opportunities in their respective countries. Private commercial nurseries normally occupy market niches. Careful projections and market studies are used to determine the levels of production required for profitability in these nurseries.

Local government managed nurseries are not commercially oriented. Seedling production is intended to meet the needs of local communities mostly within its municipality, though sometimes a nominal fee will be charged to ensure seedlings are valued by the community. Excess seedlings are sold to customers outside their territories, with the profits providing a partial cost recovery, thereby offsetting the cost of the nursery operation (Personal communication with nursery operator at Chaubas). Similarly, CFUG 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. For example, Deupokhari CFUG nursery has produced almost 4000 *Zanthoxylum armatum* (timur) seedlings that will be purchased by DFO and distributed to other communities while 500 timur cuttings were purchased by the project during training held at Patlepani, DFO managed nursery.

Training, Extension and Management services

Training and capacity building

The good facilities and highly qualified technical staff with support from project make DFO nurseries excellent training grounds for individuals willing to learn technical and management aspects of tree nursery operation. These nurseries are large and readily accessible, making them good platform for training and field visits by nursery operators and other interested groups. The staff in government nurseries often act as trainers and willing to assist users to learn skill on propagation techniques. However, small-scale nursery operators seldom benefit from trainings held in these nurseries. In the past two years of EnLiFT2 project period, TOT was offered for nursery operators in these nurseries. Although the intensive seedling production systems used in these nurseries are not appropriate for most small-scale nursery operators, these individuals may still benefit from field visits to these nurseries.

The local government nurseries are ideal venues for the formal and informal training of community members that may be undertaken by DFO staff and facilitated by staff of supporting organizations (NGOs or INGOs). Technical specialists from other institutions may be included in the training team. Training activities run by these nurseries are effective because they include enough time for community members to share their knowledge and experience and ask questions. Periodic field visits to these nurseries after formal training are useful in supplementing the technical knowledge of community members who operate local nurseries.

CFUG 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 CFUG nurseries are farmers, they are frequently able to deliver very practical and effective training to other farmers. Providing farmer-operators with TOT courses helps build their capacity as farmer nursery specialists. One of the members of Deupokhari CFUG nursery participated in TOT held at Patlepani DFO nursery in 2019.

Due to their limited size and facilities, individual nurseries are generally not used for formal training purposes. However, they can provide effective farmer to-farmer training activities. These trainings are informal and provide farmer nursery operators and farmers with 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 services

The staff of government nurseries, mainly DFO 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. One of the officers of the DFO is assigned to provide capacity building support to nursery operators. He or she is responsible to provide feedback to the nursery operators. Nursery operations are carried out by the hired nursery naike (leader) in each of the nurseries except individual nurseries. The naike is responsible to take care of the seedlings and distribute the seedlings to the communities in the district. This also applies true in case of the local government managed nurseries.

Registered private nurseries do not normally conduct extension services. However, they may provide some services to local communities, including project or individual nurseries - particularly to those who plant large number of trees. These extension services are usually limited to tree propagation and nursery management, but may also include post planting management.

In many areas where government extension services are inadequate, CFUG or project contacted individual nurseries may be the only reliable source of technical information. There is an emerging trend in project site to obtain technical skill and knowledge from Private nursery operator who provides his/her expertise on species selection, tree management and product marketing.

CFUG nursery operators often provide technical assistance to farmers within and outside their community. This assistance focuses on nursery and tree management. Good CFUG nurseries sometimes provide technical services and are frequently visited by project personnel and DFO staff. Some group nurseries become local suppliers of planting materials such as Deupokhari CFUG nursery operator collected timur cuttings from its forest area and supplied to DFO managed nursery.

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. Being one of the members of the community, they are easily understood by other farmers, thus facilitating information exchange. For instance, nursery operator of Kalapani CFUG is also the Chairperson of their CFUG and so other members of the community easily understand what he is doing for the community. Many individual nurseries are sources of tree seedlings and may broaden the species variety and information available to local residents and visitors. Individual nursery of Kalapani is also raising fruit and NTFP seedlings.

Management services

DFO nurseries have been 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. A careful documentation is being done and standardized.

Local government nurseries have a simpler organizational structure and fewer staff than DFO 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.

Private commercial nurseries have a defined organizational structure, where manager of the company controls the organizational operation. 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 regular guidance from the manager. Four to five nursery workers are being mobilized in Agroforestry private nursery at Badare of Indrabati-10.

CFUG nursery members themselves define work responsibilities. The nursery operators and short term workers are usually chosen by the CFUG committee, and other positions of the committee are elected by the community members in the general assembly meetings. Members agree upon work schedules and share labor. Frequently, a sub-group of members are appointed to run the nursery. In large group nurseries, work schedules can be difficult to implement during festivals and intensive farming periods. Nursery operations are generally documented either by respective nursery operator or by project staff.

Both individual nurseries in Sindhupalchowk and Kavrepalanchowk are exclusively managed by one family member with all other members contributing. However, nursery establishment and management are constrained by a lack of family labor and resources because they have to involve in other household and farm activities.

Choosing a best practice nursery

Several factors need to be considered to ensure the relevance of the nursery type. This chapter is intended as a decision-making tool, to help individuals and organizations identify the appropriate nurseries by their conditions and for their envisioned objectives. Important selection criteria were used as a basis for comparing the main five nursery types: DFO, local government, CFUG, registered private and individual managed nurseries were examined. The selection criteria are arranged into four main headings: goals and functions, operational features, management inputs, and external factors. Table 6 provides a comparison of the criteria by nursery types, followed by a discussion. It should be noted that there is hardly 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.

Goal and Functions

Out of the five objectives indicated in Table 6 under goal and functions, the DFO managed nurseries have a high potential for technology generation through research and innovation,

particularly the development of new technologies for government reforestation and corporate tree planting programs. For this reason, this type of nursery scored higher compared to others. The other three (local government, CFUG and Private) nurseries have a limited capacity to generate new nursery technologies, due to their limited scope of their objectives. The same is true for individual nurseries which rarely focus on developing new technologies as they are constrained by limited financial support and resources. LG and CFUG managed nurseries have a high potential for technology dissemination because of their farmer-friendly atmosphere and frequent linkage with other project, group, and individual nurseries and thus have higher score (Table 6). Farmers readily share new technologies among themselves. Farmer-to-farmer communication is generally very clear and efficient as they understand with each other's conditions. Private and Individual nurseries may have only moderate capacities to disseminate technology because of their limited linkages with other nurseries and farmers and thus they scored less.

Table 6: Comparison of nursery types by defined criteria

Selection criteria	Managed by:				
	DFO	LG	CFUG	Private	Individual
Objective and functions					
Technology generation	+++	++	++	++	+
Technology dissemination	++	+++	+++	++	++
Capacity building (training)	+++	++	++	+++	+
Income generation	-	+	++	+++	+++
Environmental education and awareness	+++	+++	+++	++	+
Operational features					
Production capacity	+++	+++	++	+++	++
Duration of operation	+++	+++	++	+++	+++
Quality of planting stock	++	++	++	+++	+++
Species diversity	++	++	++	+++	+++
Management inputs					
Financial costs	+++	+++	++	+++	+
Infrastructure	+++	+++	++	+++	+
Human resources	+++	+++	++	+++	+
External factors					
Policy support	+++	++	++	+++	+
Credit access	Na	Na	Na	++	-

Note: +++ = high, ++ = medium, + = low, - = none or non-existence, na = not applicable

Technological support has been done regarding nursery seedling production including work on potting mixtures, growing media, and size of polythene bags, drainage, fertilizer application, and length of time needed for seedlings in the nursery (about 30 cm in height) in different locations. Some species have been propagated very successfully from cuttings for long time by villagers, often using special techniques such as air layering and side grafting. These techniques were tried in both locations of DFO managed nurseries with support of farmer technician. As explained

earlier, the EnLiFT2 project has recently started testing 'timur' cutting trial at DFO managed nursery, Patlepani, Chautara, Sindhuplachowk. For this technique to be applicable under normal field conditions, greenhouse beds of suitable species would have to be established in or near nurseries, or on farmer's land. Green net for making shades have been provided by the project in all eight nursery sites.

Farmers also find local government and CFUG managed nurseries as a good place for conducting trainings for learning, as they provide an informal setting, but limited to only the communities around the periphery of community forests. Individual nurseries could be a strong potential use center for farmer-to-farmer visit, but are rarely used for this purpose as they have recently initiated these nurseries based on project support. Private nurseries that serve as training venues are often commercially-oriented and has good learning environment. Therefore, DFO and Private managed nurseries got higher score compared to others (Table 6).

The objective of earning money from the nursery varies based on the type of nurseries. Generally a nursery income generation capacity is closely related to its market orientation. Private and Individual nurseries, despite many of them being of small size and limited seedling production in project site, have a strong capacity to generate income. Because of this, they scored higher than others. This is obviously a key motivating factor for farmers and entrepreneurs who develop nurseries. CFUG 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 (Roshetko *et al.* 2010). DFO and local government managed nurseries are not designed for income generation, and they often have fiscal restrictions on commercial endeavors and so they scored less in the assessment (Table 6).

All nurseries are excellent learning centers for environmental awareness. DFO and local government nurseries create high environmental consciousness as they are part of environmental education centers of most government agencies and projects. These nurseries are also centers for various species and genetic resources, thus contributing to biodiversity conservation. CFUG nurseries also promote environmental conservation and protection among their members to enhance their farms and livelihoods (high score). Individual nurseries contribute little to environmental awareness; however this is not one of their priorities.

Operational features

As discussed earlier, annual seedling production varies according to nursery type and is determined by their demand. Private commercial and many government nurseries including DFO and local government managed nurseries have very high production targets relative to CFUG and individual nursery types (High score). However, some CFUG nurseries may produce 10,000 to 15,000 seedlings based on community demand and some market-oriented individual nurseries may also produce high level of seedlings with the assistance of hired staff (medium score). Example from case study sites in Kalapani, Kavre demonstrated that the nursery has more than 13,000 seedlings of at 10 to 15 species, but there exist lower number of seedlings (about 4000) at Daduwa individual nursery. However, during the first phase of EnLiFT project, some farmers had less than 100 tree seedlings in their homestead. Several home nurseries back then were producing 500 to 1000 seedlings for their own plantation. Private nurseries on the other hand received high score (Table 5). It is because Badare private nursery produced more than 77,000 seedlings of multiple species.

Organizational objectives determine the length of nursery operations in years. All these DFO and local government managed nurseries have the longest duration (high score). They are usually

designed to be long-term facilities, providing continuous seedling production capacity. Recently, Chaubas Bhumlu Rural Municipality provided support of about NPR 500,000 annually for the operation of their nursery. However, all nursery types are designed to meet specific seedling production targets and are not permanent. Project supported nursery operations are coterminous with a life of 3-5 years. Likewise, CFUG nurseries also last for 3-5 years, as groups tend to nominate their committee members after their tenure is finished or members have sufficiently enhanced their technical capacity (medium score). Individual and private nurseries that are privatized and evolve towards market orientation also have longer durations of operation (high score). Individual nurseries are more dynamic, usually operating for one production cycle to several years. Often individual nurseries operate intermittently over a few years.

Seedling quality is determined by a nursery operator or manager's technical capacity and access to quality tree seed source. DFO managed nurseries usually produce good quality seedlings by using their technologies/seed source and follow strict production standards and thus scoring a medium. Species diversity tends to be inversely related to the scale of nursery operation. DFO managed nurseries traditionally focus on producing high quantities of seedlings of a limited number of economically important species. In contrast, private and CFUG nurseries produce a more diverse group of species within their smaller facilities to meet the multiple socio-economic and environmental objectives of different stakeholders. Privately managed nurseries must meet market demand and so they produce high quality seedlings (high score) and the same is true in case of individual nurseries. Both tend to have the highest diversity as they produce few seedlings of diversified species to meet household livelihood needs and exploit various on-farm planting niches.

Management Inputs

Financial capital is necessary for the establishment and operation of all nursery types. The DFO and local government managed nurseries are by far the most expensive due to requirements of capital investments in land, facilities and staff costs (high score). Comparatively, CFUG nurseries cost much less to establish and operate, but they still require a dedicated budget (medium score). These nurseries require much lower financial costs as they operate based on available volunteer members. In many cases, CFUG nurseries receive financial support from projects or institutions. For individual nurseries, there are few direct financial costs required for establishment or operation (low score). Market-oriented private nurseries generally have higher operating costs that are self-supported through market sales and service provision (high score).

DFO, local government and privately managed nurseries require high infrastructure and permanent facilities to efficiently produce large quantities of seedlings and sustain continuous operations over a long period of time. Such facilities include greenhouses and shade houses, watering systems, a power supply, storage and office space, as well as vehicles. CFUG managed nurseries require a moderate level of infrastructure, less complex than the three nurseries explained above. Individual nurseries may have little infrastructure, while many individual nurseries may have none (low score).

DFO managed nurseries require higher human resources both skilled and unskilled compared to local government managed nurseries. Similarly, private commercial nurseries also require high level of human resources. These three nurseries received high score compared to CFUG (medium score) and Individual (low score) managed nurseries.

External factors

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 (Roshetko *et al.* 2010). These government policies and programs may or may not explicitly favor one type of nursery over another. Generally, implementation favors larger nurseries in all cases. Government managers prefer to deal with one or a few seedling suppliers, rather than many. DFO managed and private commercial nurseries are best situated to take the advantage of the opportunities created by these policies and programs because of their large seedling production capacity and existing links with government agencies (high score). Mandal (2019) mentioned that 50 million seedling plantation target of the current fiscal year of Nepal have encouraged many DFO managed nurseries to be developed. Local government managed nurseries are also getting advantages of this provision (medium score). Most CFUG and individual nurseries have limited, weaker access to the benefits of government policies and programs and thus they obtained low score. However, until recently, the government of Nepal with support of MOFE and MOALD has recognized the importance of CFUG and individual nurseries as a reliable source to meet the seedling demands and specific priorities of the local government.

Private and individual nurseries have also now got access to financial credit. Normally, they have assets that can be used and recognized as collaterals for loans, but now in Nepal, individual member of the group can have membership collateral to borrow loan. On the other hand, if they are of project supported nurseries, they tend to secure internal financial support and are not interested in accessing credit. Operators of CFUG 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. Individual nurseries have less access to assistance due to their small size and the fact that they are operated by a single family. Both individual nurseries have not taken any loan from any credit institutions yet, while private commercial nurseries got both loan and grant from the government. CFUG managed nursery at Deupokhari is operated through its own fund. The training and material support was however provided by the project for all nurseries. DFO and local government managed nurseries are not entitled to get credit from the credit institutions; they run through their own funding.

CONCLUSION AND WAY FORWARD

This report is the part of the overall support of the EnLiFT2 project in terms of promotion of best practice nursery in the project site and thereafter to adapt them in other part of the country. This report however represents the eight nursery cases of two project districts (Sindhupalchowk and Kavrepalanchowk), this would be useful for other districts that are implementing plantation projects. This report discusses about five important nursery types (DFO, local government, CFUG, individual and privately managed nurseries) that are also relevant in other parts of the country, and their strengths, weakness, opportunities and threats are discussed. The supporting role of these five nursery types discussed in this paper is to ensure that they fulfill farmers' needs for tree seedlings (either by supplying cash generating species: NTFP/fruit or simple timber, fuelwood and fodder tree species) since an increase in tree planting on private land will reduce the pressure on those forests used to supply timber, fuelwood and fodder, and NTFPs. It is therefore essential to establish nurseries which are responsive to farmers' needs and form part of an integrated approach to the role of trees in the existing farming systems. The nursery type could be CFUG, local government managed or private individuals, but the main goal is to provide quality seedlings with reasonable price to the farmers. In order to promote a best practice nursery, the following recommendations are made as a way forward points:

- To achieve the goal, the government and Forest Department initiatives must be directed towards identifying the needs and preferences of the farmers, and support the formation of effective extension systems which link farmer needs with nursery seedling production and appropriate research either on-farm or on-station.
- In order to integrate all extension efforts prevailing in different sites and locations of the district, the project needs to have a rather one door system for delivering the seedlings to farmers. All nurseries operators who produce seedlings in their nurseries could be assembled at one place locally recognized by farmers. In this regard, sub-divisional forest office could be an appropriate platform for distribution of seedlings to the farmers.
- The seedling distribution will not finish in a day or a month or even a season, therefore there is a need to develop suitable infrastructure at each of the distribution centers for storage. The distribution centers is entitled to charge small overhead or surcharge money to the respective nursery operators or entrepreneurs who would bring seedlings to the center for distribution and marketing.
- The one door seedling distribution system will avoid duplication of nursery promoters' work and will have a joint and collaborative efforts altogether. The existing free distribution system of government should be stopped rather it can be promoted as a grant to the farmers.
- Tree nurseries do not operate in isolation. Various types of nurseries are interdependent and maintain numerous dynamic linkages with each other and the tree planting/reforestation sector. Therefore, it is recommended to have strong network of nurseries in the district so that each of the nursery types can complement each other.
- DFO managed nurseries are a main source of technologies and information that flow to the other types of nurseries. Those inputs from this type of nurseries are often transferred

to local nurseries (group or individual nurseries) through forestry extension workers. In the context of shortage of staff, it is advisable to initiate seedling distribution center at Sub-divisional DFO office located in each of the Ilakas consisting of at least two to three local government territories as indicated earlier.

- Local government managed nurseries are generally linked with other nurseries (DFO and CFUG), and have limited direct interaction with individual nurseries. They can be a primary source of financial and material support for the establishment and initial operation of individual nurseries. Because most of Local governments have allocated enough resources for the management of tree seedling production.
- CFUG and individual nurseries are not only the recipients of information and resources, they also provide a back flow of information, innovations, seeds and seedlings to local government and DFO managed nurseries and are important sources of the seedlings for many tree planting and reforestation activities.
- DFO managed nurseries are important sources of seedlings for reforestation and tree planting activities (frequently vertically integrated activities) and therefore their focus should be producing timber and fuelwood species in their nurseries that are cheaper and can be freely distributed to farmers or groups.
- Private commercial-oriented nurseries are generally producing high value fruit and NTFP seedlings and have strong links with seedling markets. Therefore they can link the market with sub-divisional forest office for sale of their seedlings outside of the community or village.
- In future with the support of local government, other nurseries can be a center for forest extension services, transfer of technology to local communities through engagement in planting campaigns, educational program to schools and other groups, and hosting demonstrations of how plants grow and how they can be used.
- Seedling quality would be overshadowed if strong emphasis is laid on numbers of seedling to be produced. In terms of promoting a sustainable nursery, it is recommended to produce quality seedlings. Therefore the government policy should be geared to producing quality seedlings with standard criteria through a long-term seedling quality improvement programs.
- There is a need to have proper records and accounting of all the plantations that are being completed so far. This will not only save the country's resources but also make an effective plantation management system. This presents the fact that these seedlings were not of quality standard and almost all were died after planting. Considering this, there is a need of good planning and distribution system in the country.
- In order to avoid free seedling distribution system of the government, it is recommended to assist private and individual nurseries rather than competing with them. This will motivate farmers to undertake high quality nurseries locally.

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ANNEXES

Annex 1: Questionnaire for nursery stakeholder survey

Key informant name: -----

Institutional affiliation: -----

1. What types of nurseries that you have observed or in practice in terms of institutional arrangements? (Example: 1. DFO nursery 2. Local government nursery 3. CFUG nursery and 4. Private or individual nursery)

2. What is the existing seedling size of these nurseries?

3. What is the focus of nursery in terms of promoting species (such as fruit, timber, non-timber, fodder and grasses)? Tick mark (√) to the most relevant one or two only

Focus of nursery	
Forest-timber & fuelwood	
NTFPs/medicinal plants	
Fruit trees	
Fodder grasses	
Others (Flowers and vegetables)	

4. Could you please provide the practical price range of the seedlings

- Fruit trees
- Timber
- Fuelwood and fodder trees
- NTFPs
- Flowers -----
- Vegetable -----

5. How can we maximize farmers' benefit from these nurseries?

6. What is the scale of commercialization of these nurseries? Rating scale 1 = least & 3 = high

Criteria	Rating scale		
	1	2	3
Organizing capacity	Not organized	Informally organized	Organized & formally established
Type of agreements or degree of formality	Informal, with informal agreements	Formal, with informal agreements	Formal, with formal agreements
Distance between producer and buyer	Short (Max 1 intermediary)	Medium (at least two intermediaries)	Long (> 2 intermediaries)
Mode of communication for sale	Personal contact	Through Radio or newspapers	On-line marketing
Quality assurance	No information about seed source	Seed source known but not guaranteed	Seed source is defined & guaranteed
Annual turnover & staffing	Negative (-ve) and no other staff hired	Positive but managed by owner him/herself	Cost benefit ratio is +ve, and hired staff are paid

7. How seedling quality standards are maintained in these nurseries? Who will take guarantee of quality of seedlings, evaluating species, provenances, varieties and other germplasm selection?

Quality of seedlings:

Evaluating species: -----

Germplasm source: -----

8. What is the level and type of technologies used in these nurseries? (Level: 1 simple, 2 = medium and 3. High) -----

Rating criteria:

1 = Simple, seedlings are grown in a natural environment

2 = Medium, plastic and green net used with bamboo or iron frame for shade and germination

3 = High, temp is maintained, sprinkle water is circulated and iron structure is used

9. What is the management structure of these nurseries? How nursery activities are managed and operated?

10. How research and innovation activities are conducted? e.g new species and technology?

11. Are these nurseries used as training and capacity building events for local communities or what?

12. How are the extension or other services provided to local communities?

13. What do you think setting up retail nursery (eg at sub divisional level) where the wholesale plants are established at DoF nurseries.

14. What are the best practices that you have noticed or observed in terms promoting nurseries in your area?

Best practices	1 = Yes and 2 = No
1. Seed source are known	
2. Seedling sizes are defined	
3. All types of beds exist (germination, transplant and hardening beds)	
4. Seedling tagging done/ sign board exist	
5. Good record keeping system exist	
6. Timely weeding and cleaning of the nursery	
7. Root pruning are done in timely manner	
8. Seedling grading done and kept in hardening beds	
9. Others (appearance- good looking, green etc.....)	

15. What are the strengths, weakness, opportunities and threats of these four nursery models being practiced now? Make note in the respective boxes below for each of the nursery types (Ask this in the FGD)

SWOT	DFO supported	LG supported	CFUG supported	Private nursery
Strength				
Weakness				
Opportunities				
Threats				

16. **Choosing the best practice nursery** (based on the interview above or in a FGD, please mark the score in the respective boxes) Rating score: +++ = very high, ++ = High, + = low, - = very low and NA = Not applicable.

Selection criteria	DFO	LG	CFUG	Private
Goal and functions				
1. Technology generation				
2. Technology dissemination				
3. Technology innovation				
4. Capacity building				
5. Income generation				
6. Environmental education and awareness				
Operational features				
1. Production capacity				
2. Duration of operation				
3. Quality of planting stocks				
4. Species diversity				
Management inputs				
1. Financial costs				
2. Infrastructure				
3. Human resources				
External factors				
1. Policy support				
2. Credit access				

Annex 2: List of species in the trial of Patlepani nursery

S.N	Botanical name/Scientific name	Common name	Local name
1	<i>Zanthoxylum armatum</i> DC.	Winged prickly Ash	Timur
2	<i>Citrus lemon</i> Burm.	Lemon	Kagati
3	<i>Ficus semicordata</i> Buch. Ex.J.E. Smith	Wedgelead fig.	Raikhanyu
4	<i>Purnus sarasodies</i> D.Don	Wild himalayan cherry/ sour cherry	Paiyu
5	<i>Juglans regia</i> L.	Walnut	Datae okhar
6	<i>Phyllanthus emblica</i> L.	Indian gooseberry	Amala
7	<i>Edgeworthia gardener</i> (Wall.)Meisner	Nepalese paperbush	Argeli
8	<i>Morus alba</i> Mora.	Mulberry	Kimbu
9	<i>Leucaena leucocephala</i> (Lam.)de Wit	White leadtrees/ river tamarind	Ipil Ipil
10	<i>Flemingia congesta</i> var. <i>Semialata</i> (Roxb.)	Large leaf flemingia	Bhatmase
11	<i>Paulownia tomentosa</i> (Tuunb.) Steud.	Princess tree	Paulonia
12	<i>Purnus sarasodies</i> D. Don	Tea plant	Cheyapatti
13	<i>Saurauia napaulensis</i> DC.	Gogan	Gogan
14	<i>Texus baccata</i> L. Hulme	Common yew	Lauth salla
15	<i>Sapindus makorossi</i> Gaertn.	Soapberry	Rittha
16	<i>Bauhinia Purpurea</i> L.	Purple orchid tree/ butterfly tree/camel foot	Taki
17	<i>Pinus Patula</i> Schiedeex Schldtl .& Cham.	Patula pine	Pate salla
18	<i>Choerospondias axillaris</i> (Roxb.) B.L. Burt & A.W. Hill	Hog plum	Lapsi
19	<i>Delonix regia</i> (Hook.)Raf.	Flame tree	Gulmohor
20	<i>Bauhinia variegata</i> L.	Orchid tree	Koiralo
21	<i>Ficus auriculate</i> Lour.	Elephant ear fig	Nimaro
22	<i>Artocarpus lakoocha</i> Roxb.	Monkey jack	Badahar
23	<i>Melia azedaarch</i> L.	Chinaberry tree	Bakaino
24	<i>Cinnamomum camphora</i> (L.) J. Presi	Camphor laurel	Kapur
25	<i>Callistemon citrinus</i>	Crimson bottlebrush	Kalki
26	<i>Paris polyphylla</i> Sm.	Herb Paris	Satuwa