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Analysis of the Changes in Small-Scale Nursery Operations for Equitable and Active Forest Management in Nepal: Experiences from EnLiFT2 project



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Our Cover

Shrestha Chitragupda nursery at Kalapani of Dhungkharka, Kavrepalanchok district by Bishnu Hari Pandit, EnLiFT2, Agroforestry Research and Development Consultant.

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Analysis of the Changes in Small-Scale Nursery Operations for Equitable and Active Forest Management in Nepal: Experiences from EnLiFT2 project

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List of Acronyms

ACIAR	Australian Centre of International Agricultural Research
AFRC	Agroforestry Resource Center
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
FRTC	Forest Research and Training Center
GSS	Gramin Samudaik Santha
INGOs	International Non-Government Organizations
LG	Local Government
MOFE	Ministry of Forest and Environment
NPR	Nepalese Rupee
NAF	Nepal Agroforestry Foundation
NGO	Non-Government Organization
NTFPs	Non-timber Forest Products
TISC	Tree Improvement Silvicultural Component
RM	Rural Municipality
SCPGN	Shrestha Chitra Gupta Pasupalan and Nursery
SWOT	Strength, Weakness, Opportunity and Threats
TOT	Training of Trainers

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Executive Summary

This paper provides information on the changes of nursery practices as a result of the implementation of EnLiFT2 (Enhancing livelihoods from improved forest management) project. These changes have been assessed using certain criteria such as: knowledge and skill of nursery operator and managers; nursery size and production capacity; general nursery set up and facilities (irrigation, seedling container, growing media and fertilisation, general outlook and grading); quality of the planting stock (sturdiness, health, color of leaf and foliage, stem form), and the Strength, Weakness, Opportunity, and Threats (SWOT) analysis of the nurseries. The methodology involved desk review and analysis; nursery visit and data recording; consultations with nursery stakeholders and SWOT analysis. The theory of change has been explained as a process of change in nursery operations that includes active engagement of the local level nursery stakeholders; starting with production of small-scale home nursery approach; establishing a reward system for the successful nursery operators; using Training of Trainers (ToT) approach; sharing knowledge and skills from outside Nepal; conducting shared learning exercises; testing the quality standards with wider level of stakeholders; involvement from grassroots to policy level stakeholders in developing the nursery criteria and standards; sharing of the nursery standards with Provincial level governments and Division Forest Offices (DFOs); and creating a self-assessment culture for improvement of nursery in the future. In order to do this assessment, six nurseries (3 DFO managed including one local government supported and 3 privately managed) were selected out of 15 partially supported by the project. The community managed nursery was not selected as it did not exist at the later part of the project, due mainly to lack of fund to provide salary to the nursery operator.

The success of tree planting depends on the quality of seedling used. With the exception of a few commercial private tree nurseries in the past, government managed nurseries hardly met the quality of seedlings. They were focused on meeting targets rather than quality. But following the project (EnLiFT2) intervention, they have improved the quality of seedlings. The DFO managed nurseries have had relatively adequate human resource and equipment for the management of planting stocks such as seed beds, transplant beds and hardening beds, watering systems and shade. Despite the promising start, the Local Government supported nursery also encountered financial shortage like that of community forest nursery explained above. In terms of commercial orientation, private nurseries are profit-oriented, while the government nurseries are still target oriented. Private nurseries have both skilled and non-skilled workers and have been making good income as well as profit unlike other nurseries. The DFO managed nurseries do not sell their seedlings. However, they are relatively better placed for training of community members and individuals. In terms of skilled human resource, private nurseries are better off and have been helpful in conducting skilled oriented training to the farmers and communities during the TOT. High value tree seedlings are the sources for private nurseries that can have better link to market. One of the private nurseries that started from a small home nursery is now grown up into a commercial nursery at Dhungkharka of Kavre district.

Overall, human resources in all three types of nurseries have upgraded their knowledge and skills in producing quality seedlings. Likewise, seedling production capacity of all nurseries has been enhanced. However, in terms of sale or distribution, DFO managed nurseries have less sale and high rate of restocking (>52%) for future planting. The rate of change in infrastructure facilities (seed bed, transplant bed, hardening bed, hyko bed, soil sterilization, sieving facilities etc.) is higher in Private nurseries with 5.2 (from 10.5 to 15.7 points) compared to DFO nurseries 4.3 (from 12.5 to 16.8 points). Similarly, the rate of change in seedling quality indicators (sturdiness, health, color, stem and root forms) and overall score are highest in the case of private nurseries. The rate of change is almost double of what is observed in DFO and local government (LG) supported nurseries. It can be concluded that the overall change in seedling quality parameters is higher with private nurseries because it is understood that the private nurseries are more commercially-focused, which appears to provide the strongest motivating factor to produce quality seedlings.

Introduction

The production of seedlings in forest nurseries started with the initiation of plantation research in the early 20th century in Nepal (Pandit et al., 2020). Many researchers and practitioners worldwide have recognised the importance of planting seedlings with desirable attributes, and that these attributes are associated with successful seedling survival and growth after planting in the field (Villar-Salvador et al., 2010; Munjuga et al., 2013; Grossnickle and MacDonald, 2018). To assist with that process, various seedling quality assessment procedures that measure numerous morphological and physiological plant attributes have been designed and applied (Quayle et al., 2001; Richie et al., 2010; Gregorio et al., 2010).

Forest nurseries in Nepal have been producing large number of seedlings of different forest tree species every year for plantations, however, the quality of nursery stock has always been a major question. In general, poor-quality seedlings have been produced; such seedlings could not be adapted to the difficult and harsh plantation sites. As a consequence, the survival of seedlings has been poor in many plantations. Slow development and death of tree seedlings had been a problem common to many rural development programmes, which has led to many farmers losing interest in tree planting out of frustration (Munjuga et al., 2013; Grossnickle and MacDonald, 2018; Pandit et al., 2020).

In view of the above problems, the EnLiFT2 (Enhancing livelihoods from improved forest management) project implemented capacity building and supported programmes related to production of best quality seedlings in all government (DFO and Local Government - LG), community and privately managed nurseries. First, based on interviews with nursery stakeholders and an analysis of the nursery work implemented in the past 10 years in two project phases (first phase: 2012-2018 and second phase: 2019 to 2023 extended to 2024), a theory of change was developed, which identified a number of drivers for or pathways to arrive at the production of good quality seedling (Kusters et al., 2022) (see section 3.5). The project supported nurseries, however, differed in various aspects of nursery development parameters such as available human resources, area or size and production capacity, nursery set up and infrastructure facilities, types and qualities of planting/nursery stock, health and sturdiness of seedling and mechanisms for institutional support services. Based on these parameters, the seedling quality standards and their rating criteria were developed (Annex 1), tested and verified in various meetings and finally used to assess the changes in nursery practices. The intent of this paper is therefore to provide readers with an overall perspective on the change of nursery practices for better quality seedling production using the standards that are being developed by the project, together with a Strength, Weakness, Opportunity and Threats (SWOT) analysis of different types of nurseries. The questions answered here, are how have the changes in nursery practices taken place and what were the drivers of change.

Objectives

The general objective is to assess the changes in overall nursery operation and practices of the selected nurseries in Nepal.

The specific objectives are to assess the changes in:

- the knowledge and skill of nursery operator and managers,
- the nursery size and production capacity,
- the general nursery set up and facilities (irrigation, seedling container, growing media and fertilization, general outlook and grading),
- the quality of planting stock (sturdiness, health, color of leaf and foliage, stem form)
- the Strength, Weakness, Opportunity, and Threats (SWOT) analysis of the nurseries being selected for this study.

Methodology

Desk review and analysis

Relevant books, journal papers, manuals, brochures, and reports were reviewed to get insights of forest nurseries and nursery stocks quality assessment.

Consultations with nursery operators and managers

A checklist was prepared for consultation with nursery operators and managers. Staff of the EnLiFT2 project were involved in the documentation of changes in nursery practices. Of the total 15 nurseries supported by the project in the past five-year period, 6 nurseries (3 government managed and 3 privately managed) were deliberately chosen and consulted for documentation of changes. A 'before' and 'after' approach was adopted in recording the value of the change in nursery practices. We used most of the criteria and rating scale of the nursery accreditation guideline developed with FRTC and Provincial government Ministry of Forest and Environment (**Annex 1**).

Nursery visit and data recording

All of the six nurseries were observed and cross-checked against the findings of the earlier consultations. During the nursery visit, EnLiFT2 staff together with the respective nursery operator assessed each of the criteria being used in this evaluation. The nursery visit and association observations was a most effective approach of evaluation (Thompson, 1985), especially in association with other methods. The scores and ratings of each nursery at the 'before' stage of the project were assessed based on the judgment of the nursery operators and visiting staff.

SWOT analysis

SWOT analysis was done with three types of nurseries, DFO managed nursery, LG supported and private nurseries in order to verify the results obtained from consultation and nursery site visits. The general characteristics and observed changes of the nurseries are discussed in the beginning of this report.

Theory of Change: A 10 years of nursery work

In this section, we have listed below 10 activities or conditions towards which the changes in nursery practices taken place.

Active engagement of the local level nursery stakeholders

The most important activity included the active engagement of the nursery stakeholders including farmers, leasehold and community forest user group (CFUG) members, DFO staff and civil societies in production of good quality seedlings. At the beginning of the first phase, home nursery training was organized in six communities (three communities each from two project districts - Kavre and Lamjung) involving at least 30 participants, mainly farmers, per community. This resulted in a network of at least 180 farmers in six communities of two districts of Nepal.

Starting with the production small scale home nursery approach

After the training, each of the communities nominated two leader farmers (one male and one female) who then started home nurseries producing at least 10,000 seedlings of various species, mainly fodder trees and grasses including fruit and timber trees, annually in each of the six sites. This resulted in production of more than 300,000 seedlings of various species with survival rates of at least 50% in the field after plantation. This activity continued till the end of first phase, and resumed again in the second phase with addition of one district, Sindhupalchok and phasing out of Lamjung district in 2018.

Establishing a reward system for successful farmers

Each of the community members who were successful in establishing a appropriate forest garden by planting a hedge row of at least 100 trees in their farmlands were awarded a small prize of Nepalese Rupees (NPR) 2500/farm. Each community was successful in producing a capable nursery manager that could provide enough seedlings for these plantations. Two trained nursery operators from Lamjung, one male (Mr. Bhola Paudel) and one female (Ms. Radha Bisural) are still active in nursery activity and are earning sufficient money through the sale of nursery stocks to support their livelihoods.

Starting with a training of trainers' approach

In the second phase, the project facilitated a total of three sets of nursery related trainings in Sindh and Kavre districts involving 76 participants, of which almost one-third participants were female (Table 1). The first set of two training sessions (one per district) was devoted towards technical matters related to basic nursery facilities such as seed bed, seedling bed and/or hardening bed preparation with soil sterilization and sieving, use of appropriate containers, potting mixture preparation, and infrastructure facilities for quality seedling production. General nursery seedling standards such as sturdiness, health, colour, stem and root forms were discussed, and the seedling quality assessment criteria implemented through negotiation.

Sharing knowledge and skill of experts from outside Nepal

The concepts of hyko trays, elevated beds including hardening bed system and quality seedling assessment criteria were introduced by one of the professional project consultants, Dr. Edwin Cedamon. This was one of the very important interventions being implemented from the project side for the success of the production of quality seedlings.

Shared learning exercise brought a high level of ownership to produce better quality seedlings

After a year or so of the second phase program, a follow up or refresher training was held for almost the same participants as the shared learning exercise in both districts. Most of the sessions were facilitated by the participants themselves in close observation from the project team. In the second set of training, the quality seedling assessment standards were discussed and refined for further application. At the end of this training, a draft five day long training '**manual**' was developed, which included details on specific standards for producing good quality seedlings.

Table 1 : Nursery training facilitation

S N	Name	Date	Gender Participation		Institutional participation			Total
			Female	Male	DFO staff	Farmers	NGO/project	
1	Basic nursery set up training, Kavre	Mar-19	7	11	2	13	3	18
	Basic nursery set up training, Sindhu	Apr-19	4	9	3	8	2	13
2	Refresher (TOT) Nursery training, Sindhu	Feb-20	3	10	3	6	4	13
	Refresher (TOT) nursery training, Kavre	Apr-21	3	6	2	4	3	9
3	Nursery mgt. and certification	Feb-22	8	15	3	16	4	23
Total			25	51	13	47	16	76

Source: Records of the training programs

Testing of seedling quality standards and criteria with wider level of stakeholders

The last or the fifth training was organized mainly for testing the manual developed earlier through the participatory exercise in the beginning of 2022 (Table 1). During this training, all of the skilled nursery practitioners across the project sites, including Lamjung district, participated and provided their input to review the manual and refine the criteria for nursery standard assessment. A total of 76 participants including project, DFOs and farmers groups and organizations participated in the three main training sessions (Table 1).

Involvement from grassroots to policy level stakeholders in developing the quality seedling standards

Throughout the whole process, stakeholders such as community members, non-government organisation (NGO) workers, cooperative and company representatives, and municipality stakeholders, DFOs and Director General of Forest Research Training Center (FRTC) from the government were involved very actively to finalize the manual and the quality standard rating criteria. This created a good environment in terms of coordination and a strong co-design element, which is supporting the implementation of nursery work on the ground.

Sharing of nursery standards at Provincial level of government and DFOs

In February 2023, exactly one year after participatory development process, we, FRTC and the EnLiFT2 project team shared the seedling quality accreditation standards among 40 DFOs and Forest Conservation officers of 13 districts, including the Minister and Secretary of the Ministry of Forest and Environment, Bagmati Province, in a workshop held at Dhulikhel, Kavre.

Creating a self-assessment culture for continuous improvement in future

Regular follow up and monitoring of the nursery work made the nursery owners or managers more reflective on their practices and self-motivated towards producing good quality seedlings. The focus on a participatory approach to developing the standards helped to overcome the resistance of some of the government nurseries to change, a claim which is supported by the fact that Budol nursery is now becoming a 'number -one' category nursery.

Nursery selection for the study

Of the 15 nurseries being supported by EnLiFT2 project in the second phase program period in Sindhupalchok and Kavrepalanchok districts, six nurseries (Two DFO managed- one each in Kavre and Sindh districts; two Privately managed- one from Chautara cluster and one from Bhumlu cluster Municipalities; one from a LG supported Nursery and the remaining one from the peripheral cluster-Bethanchok R Municipality) were selected (Table 2). The Community managed nursery from Deupokhari of Sindhupalchok district was no longer operational. This nursery no longer exists there, and there are no other community forest based nurseries among the EnLiFT2 project supported nurseries. Therefore, the analysis of a community-based nursery could not be included in this study. The main reason for the collapse of the community supported nursery was because of shortage of funds to pay for the nursery operator's salary, followed by a lack of availability for a Community Forest plantation area.

Table 2: Selected nurseries

Name	Location: Municipality and district	Managed / or supported by	Ownership
1. Patlepani Nursery	Chautara Sagachok-6, Sindhupalchok	DFO	Government
2. Budol Nursery	Banepa, Kavrepalanchok	DFO	Government
3. Chaubas Nursery	Bhumlu Rural Municipality, Kavrepalanchok	Local Government supported	Government
4. K & K enterprise	Bhumlu, Kavrepalanchok	Private individual	Private
5. Siddhartha Nursery	Chautara Sangachok-13, Sindhupalchok	Private individual	Private
6. Shrestha Chitra Gupta Pasupalan & Nursery firm	Bethanchok R Municipality-2, Kavrepalanchok	Private individual	Private

General Characteristics of the selected nurseries

DFO managed nurseries

The Department of Forest established one main nursery each in Budol of Kavrepalanchowk and Patlepani of Sindhupalchowk districts to support reforestation and community tree plantation programs three decades ago. In the beginning, these nurseries were primarily focused on meeting government targets for seedling production, often at the expense of quality. However, in recent times, both nurseries have recognized the importance of producing high-quality seedlings on both private and government lands. The Division Forest Office Nurseries stand out for their commitment to nurturing healthy and robust seedlings of various tree species. The shift towards quality over quantity ensures the success of reforestation efforts and contributes to the conservation of native tree species in recent times, especially after collaboration with the EnLiFT2 project. Both nurseries have made significant improvements in their infrastructure, seedling quality and operational efficiency during recent times (Photo 1 & 2). The Division Nursery has embraced traditional methods of seedling production while maintaining a commitment to innovation. Although they haven't generated new technologies, their expertise in seedling nurturing has evolved, contributing to more successful transplantation and forest regeneration.



Photo 1: Patlepani nursery, Chautara Sindhupalchok



Photo 2: Budol nursery, Banepa Kavrepalanchok

Local Government supported Nursery

The Chaubas-Bhumlu Rural Municipality in Kavrepalanchok district established a nursery in 2019, following a Training of Trainers (TOT) program on nursery management organized by the EnLiFT2 project and the DFO at Patlepani nursery in Sindhupalchowk district. This nursery aimed to produce at least 30,000 seedlings of more than 15 species, catering to the demand of local communities. In the past, nurseries were managed by the Panchayat system, but with the declaration of the Federal Republic of Nepal in 2008, the responsibility shifted to local government officials and Mayors. However, despite its potential, the nursery is currently facing a dire situation, with limited funds leading to its almost complete collapse. Despite the promising start, the nursery encountered financial challenges that led to its current state of disrepair. The lack of funds has severely impacted on its operations, the inability to pay the caretaker resulting and the cessation of activities. The situation has been exacerbated by the lack of adequate water resources, further impeding seedling growth and care (Photo 3).



Photo 3: Local government managed nursery at Chaubas, Bhumlu Kavrepalanchok

Private Nurseries

A total of three private nurseries are discussed below for their general characteristics. Out of the three private nurseries, each of them have unique characteristics. For instance: K and K Enterprise's upgraded to the Agroforestry Resource Centre and their independent seed production showcases the potential for growth and improvement. Siddharth Nursery, despite producing fewer seedlings, operates successfully by ensuring quality and reliability in its offerings. And the Shrestha nursery grew up during the EnLiFT2 project period and focuses more on the production of indigenous fodder tree seedlings and fruit trees.

K and K nursery enterprises

The Agroforestry Resource Centre (AFRC) Private Limited Company, formerly known as K and K Enterprise, is a renowned nursery located in Banepa Nepal as a wholesale and retail nursery with a production center at Bhumlu. The K and K nursery enterprise is a producer nursery established about 10 years ago, but remained active during recent times. It offers a wide range of planting stock, including seedlings and seeds, and provides training programs for farmers and student interns. The nursery claims an impressive annual production capacity of approximately 4 lakh seedlings, spanning over 70 diverse species, mainly fodder grasses slips. Trees including fodder, fruit and timber species are generated at the rate of at least 10,000 to 15,000 seedlings every year. With upgraded infrastructure, including clean restrooms and a cold room for storage, the nursery ensures the preservation of plant health during transportation. Notably, it provides training to over 1000 individuals annually, contributing to sustainable farming at the local level. This nursery's primary income sources are seedlings and seed sales, along with training programs, and it has gained a competitive edge by cultivating unique plant varieties. Overall, the Agroforestry Resource Centre stands as a leading nursery, admired for its high-quality planting stock and significant contributions to the reforestation and plantation projects in Nepal (Photo 4). The EnLiFT2 project support was recently acknowledged as very useful in this success. The nursery manager was hired as a skilled resource person for conducting the fruit trees grafting techniques in a five days nursery training held in April 2022.



Photo 4: K & K Nursery/ Agroforestry Resource Center (AFRC), Bhumlu Kavre

Siddhartha Nursery

Siddhartha Nursery, established five years ago in Chautara, specializes in seedling production, contributing to local reforestation efforts. With an annual production of 8,000 seedlings, the nursery prioritizes quality and customer satisfaction. While not engaged in training programs, it participates in environmental awareness initiatives. The nursery's limited species diversity doesn't hinder its reputation for providing reliable and healthy seedlings (Photo 5). Financially supported by a loan, it remains the preferred source of seedlings in the community due to its unique market position with no direct competition. Siddhartha Nursery, founded by Ram Sharan BK in Chautara, has been a valuable contributor to seedling production and environmental conservation for five years. With a focus on quality seedlings and its trusted service, the nursery is sought after by individuals and government agencies. While not conducting internal programs, its involvement in external initiatives reflects a commitment to environmental awareness. EnLiFT2 support was provided in the form of green netting and plastic sheets for germination, transplant beds and other standard polybags and training, which helped a lot with the reorganization of the nursery to set up and produce quality seedlings (Photo 5).



Photo 5: Siddhartha Nursery, Shreechhap Chautara, Sindhupalchok

Shrestha Chitra Gupta Pasupalan Nursery

The nursery, spread across an area of 1.5 ropani, has been operating efficiently under the sole guidance of its founder, Mr. Prem Shrestha (Photo 6). The primary objective of this nursery is seedling production of fodder trees, catering to various species such as *Sauraula Nepalensis*, *Brassaiopsis hainla*, and *Morus alba*. But now this nursery is slowly directed towards commercial production of fruit trees such as Kiwi, Avocado, walnut and pear, and NTFPs such as *Texus baccata*, *Zanthoxylum armatum* (timur) and *Emblica officinalis* (Amala) tree seedlings because of immediate cash needs. Once operating as an individual

nursery, it is now officially registered and known as 'Shrestha Chitra Gupta Pasupalan and Nursery (SCPGN) Firm'. The nursery has actively participated in various educational and awareness programs. This engagement in community initiatives demonstrates their commitment to environmental awareness and sustainability practices, further enhancing the nursery's reputation. The nursery has fostered a positive relationship with Gramin Samudayik Sanstha (GSS), which also purchased seedlings from this nursery in addition to EnLiFT2 project. This collaboration has contributed significantly to the nursery's success and has helped establish its presence in the local market. Although they haven't explored new technologies, the nursery's commitment to making top-quality seedlings has earned them a great reputation with customers and partners. By staying dedicated to maintaining excellent seedling stock and thinking about offering more training and promotions, the nursery is set for more growth and success in the future.



Photo 6: Shrestha Chitra Gupta Nursery, Bethanchok R Municipality-2, Kavrepalanchok

Assessment of changes in nursery operations and practices

Changes in small scale nursery operations are discussed in the following four sub-sections, based on the quantitative review of their activities and operations.

1. Changes in knowledge and skill of the nursery operator and managers
2. Changes in nursery size and production capacity
3. Changes in the general nursery set up and facilities
(Irrigation, seedling container, growing media and fertilization, general outlook and grading),
4. Changes in the quality of the planting stock
(Sturdiness, health, color of leaf and foliage, stem form)

Changes in knowledge and skill of the nursery operator and managers

Standards for human resource requirements are judged on the basis of individual skills/knowledge and experience with nursery operations and quality seedling production. Here DFO managed nurseries have slightly higher scores in terms of knowledge and skill in managing forest nurseries, while in terms of operational knowledge and skill, privately managed nurseries are highest, followed by the DFO and LG supported nurseries (Table 3).

It is obvious that DFO managed nurseries are supervised by trained as well as academically qualified officer. Overall, it shows that all the three types of nurseries' human resources have upgraded their knowledge and skills in producing quality seedlings (Table 3). They have also upgraded their knowledge and skill in technical as well as managerial (including record keeping and gender inclusion) capacities. Both nurseries have their female nursery operators now.

Table 3: Technical human resource capacity

Criteria & standard	DFO managed		Local Govt supported		Privately managed	
	Before	After	Before	After	Before	After
1. Knowledge and skill of nursery manager	2.0	3.0	0	2.0	1.3	2.3
2. Knowledge and skill of nursery operator	1.5	2.5	1.0	3.0	1.3	2.7
Total score	3.5	5.5	1.0	5.0	2.6	5.0
<i>*Rating scale and criteria were used from Annex 1- Standard 1 & 2</i>						

Changes in nursery production capacity

Forest nurseries are an essential part of forestry in the project area. Each year for the last three years, between 1.4 lakhs and 2.4 lakhs plants (Total = 580854) have been produced from these six nurseries to extend or restock (Total = 302991) privately and nationally owned forest (Table 4). In addition, for many years considerable numbers of trees have been exported to other districts. During the peak COVID-19 period, the DFO managed nursery at Patlepani had the largest amount of restocking

compared to other nurseries. Over all, the restocking rate was more than 52%. Therefore, any stocktaking system must be well designed to generate greater profits and support seedling distributions in the future.

Table 4: Seedling production and distribution trends

Name	2020/21		2021/22		2022/23	
	Produced	Restocked	Produced	Restocked	Produced	Restocked
1. DFO Budol nursery	19413	11180	38597	11446	48040	16530
2. DFO Patlepani	83928	56638	91711	39150	40140	39000
3. LG nursery	32123	18532	32121	25500	19503	9113
4. Shidantha nursery	13571	12740	16508	4843	7000	5000
5. K & K Nursery	77391	19600	15029	7929	15849	6928
6. Shrestha nursery	13127	7750	7162	3671	9641	7441
Total	239553	126440	201128	92539	140173	84012

Changes in the general nursery set up and facilities

All of the nurseries should have access to road/transport and market facilities with enough space for tools/equipment storage, and facilities for irrigation, electricity and fencing infrastructure. Together with key infrastructure, nursery facilities are needed such as seed/ germination bed, seedling bed and or hardening beds with soil sterilization and sieving facilities for quality seedling production. This should involve appropriate seedling containers (hyko trays), potting mixtures (planting media- biochar), grading and cleanliness of the nursery. The overall rate of change in infrastructure facilities is relatively high in Private nurseries with 5.2 (15.7 – 10.5) compared to DFO nurseries 4.3 (16.8 – 12.5) and LG supported nurseries 5 (14-9) (Table 4). The changes were dependent on the support provided through the project in providing green net and plastic sheets for roofing of germination beds and transplant beds. The elevated hardening bed making exercise held during training also helped to facilitate changes in nursery facilities. Access to road and transport including irrigation facilities were already there in case of most government nurseries. This is the primary reason why the overall rating for government (particularly DFO) nurseries is higher (score =16.8) than LG (score =14) and private managed nurseries (score 15.7) (Table 5).

Table 5: Nursery set up and facilities

Criteria	DFO		LG supported		Private	
	Before	After	Before	After	Before	After
1. Infrastructure- road, market, storage, irrigation, electricity & fencing	3.5	3.8	2.0	3.0	2.2	3.2
2. Facilities for various types of beds- Seed bed, transplant & hardening beds	2.5	3.0	1.0	2.5	1.3	2.8
3. Appropriate seedling container with hyko (elevated) trays	2.0	3.0	2.0	2.5	2.3	3.0
4. Potting mixture with bio-fertilizer and drainage enhancers	2.0	3.0	2.0	3.0	2.0	3.0
5. General outlooks of nursery in terms of grading and cleanliness	2.5	4.0	2.0	3.0	2.7	3.7
Total	12.5	16.8	9.0	14.0	10.5	15.7

**Rating scale and criteria were used from Annex 1- Standard 3 to 7*

Changes in the quality of the planting stock

Changes in seedling quality were measured based on their robustness of the stem (sturdiness quotient); whether the seedlings are free from pest & diseases; whether there are any mechanical or physical injuries on the plants; and the absence of stem rotting. Furthermore, the colour of seedling leaves and foliage should be dark green/ green deep with no inappropriate pale-green foliage; they should have developed a good root system; and, there should be no evidence of root deformations. In the prevailing context of planting material production in Nepal's forest nurseries, a sturdiness quotient of up to 10 or less is suggested for selecting nursery stock for planting. Any plant or seedling is said to be healthy when it is free from pests and diseases, and at the same time, it should not have any mechanical injuries and physical damage. Color of foliage or leaves of seedlings is a general indicator of seedling quality and can vary by species and time of the season. Yellow, brown, or pale-green foliage indicates lower vigour than dark green foliage (Haase, 2007). A deformed root obstructs the uptake of water and nutrients from the soil and a bent or looped primary root does not provide a strong base for the anchorage of the growing plant (Harrison et al., 2008 cited by Takoutsing et al., 2013).

The results indicate that the rates of change in seedling quality indicators and overall score are highest in the case of private nurseries. The rate of change in quality indicators is almost double of what is observed in DFO and LG supported nurseries (Table 6). It is understood that the private nurseries are more commercially-focused, which appears to provide the strongest motivating factor to produce quality seedlings.

Table 6: Sturdiness, health, color of foliage, stem and root form

Criteria	DFO		LG supported		Private	
	Before	After	Before	After	Before	After
1. Sturdiness	3.0	3.0	1.0	2.0	1.7	3.2
2. Health	2.0	3.0	2.0	3.0	2.3	2.8
3. Color of foliage	2.0	3.0	3.0	2.0	2.3	3.3
4. Stem form	2.5	2.5	2.5	2.5	1.5	2.7
5. Root form	2.5	3.0	2.5	2.5	2.2	3.0
Total	12.0	14.5	11.0	12.0	10.0	15.0
<i>*Rating scale and criteria were used from Annex 1- Standard 8 to 12</i>						

Strength, weakness, opportunity and threat analysis of selected nurseries

SWOT analysis is a strategic planning and management technique used to help a person or organization involved in business competition or project planning. It is sometimes called situational assessment or situational analysis. Strengths, weaknesses, opportunities, threats (SWOT) analysis includes an examination of both internal factors (strengths and weak-nesses) and external factors (opportunities and threats) that can have an influence on the success of any enterprise (Cernusca et al., 2018). In this section, three types of nurseries have been assessed in terms of their S (Strength), W (Weakness), O (Opportunities) and T (Threat).

Strengths

In this section, we tried to assess each of the nursery types on the basis of their strengths in promoting their business. DFO nurseries have reliable seed sources, sufficient, secured space for the nursery, and availability of transport and storage facilities with a regular workforce; while private nurseries are more inclined to a commercial orientation, maintained quality standards with limited start-up costs. Local government supported nurseries are more transparent and are found to have provided local government areas for seedling supplies and they distribute seedlings free of costs. Species are chosen based on priority of the officer (DFO nursery) or the ward chairperson (LG nursery) (Table 6).

Weakness

Weaknesses of the nurseries were assessed in terms of their capacities to run a nursery business, how they maintain operations in relation to competitors, and whether safeguards were in place against possible risks that can create problems in their business. For instance: the DFO and LG supported nurseries lack experience in key nursery business skills and seedlings are produced on a seasonal basis. On the other hand, the private nurseries lack transparency and are more dependent on a particular individual's skill and knowledge for the promotion of their business (Table 6).

Opportunities

Opportunities exist locally to develop a nursery business when there are farmers' coops or networks nearby that the nursery will supply with seedlings. However, they only buy the seedlings for individual farmers and other stakeholders. The result revealed that in the government nursery (Budol) there is increasing interest in ornamental and fruit tree seedlings because of nearby urban centers. Government support and services are available for private as well as DFO nurseries. Different organizations revealed interest in supporting and working in collaboration with private nurseries, and therefore these nurseries may best be able to benefit from these emerging opportunities.

Threats

We tried to assess the threats that are affecting these nurseries. DFO nurseries have conflicts with Local Government activities, particularly in relation to political preferences for leadership positions. Staff are involved directly or indirectly in political parties, which is one of the reasons why DFOs are transferred to other districts quite frequently. The change of the staff occurs regularly with the change of the government. This is evidenced from the fact that DFOs are quite frequently transferred to other districts. In Sindhupalchok district itself, at least three DFOs were transferred during the last 4-5 years. In addition, there is always fear of competition from outside nurseries in terms of sale and distribution. Inflation has led to price rises, which have negative influences on private nurseries (Table 7) and there is always competition with other nurseries (Whitte et al., 2016). Extreme climate events, seasonal purchasing trends, and as mentioned, the frequent transfer of DFO staff are the main threats for smooth functioning of the DFO nurseries. Moreover, the LG supported nurseries face funding crises, which limits their abilities to pay the salaries of nursery operators.

Table 7: SWOT analysis

Nursery types	Strength	Weakness	Opportunities	Threats
DFO managed nurseries	<ul style="list-style-type: none"> • Reliable seed source • Sufficient space • Free & readily available seedlings • Road, transport & store available • Secured home for employee • Funds assured from the government 	<ul style="list-style-type: none"> • Delayed release of funds • Mismatched with community choices • Management limited to seasonal basis • Lack of business skill 	<ul style="list-style-type: none"> • Needs to focus on farm tree growing • High potential to expand the number of fruit/ornamental tree species • NGOs and private organizations showing interest for collaboration 	<ul style="list-style-type: none"> • Target oriented • Change in political preferences • Curtailing of species selection and distribution • Conflict with local government
Local government managed nurseries	<ul style="list-style-type: none"> • Locally governed • Covering whole Palika area • Free distribution • Awareness at local level • Transparent 	<ul style="list-style-type: none"> • Lack of technical knowledge • Mgt. depends on the choice of ward chair • Lack of quality • Improper fund allocation 	<ul style="list-style-type: none"> • Women and poor people employed • Opportunity for fruit tree growing 	<ul style="list-style-type: none"> • Political instability may hinder long-term running of the nursery • Must rely on outside technical support • Political influence in distribution • Funding crisis
Private nurseries	<ul style="list-style-type: none"> • Cost effective • Commercially oriented • Sustainable • Quality standard maintained • Limited startup risk 	<ul style="list-style-type: none"> • Competitor can offer similar products quickly • Limited flexibility in pricing • Mgt. limited to private entrepreneur • Lack of transparency 	<ul style="list-style-type: none"> • Scope for collaboration with other SHs • Matches with Govt planning for local economy growth • Opportunities for growing fruit seedlings 	<ul style="list-style-type: none"> • Change in regulation can impact the business • Competition between nurseries • Natural disaster • Inflation and price rise

Conclusions

The findings indicate that private nurseries are thriving in comparison to other forms because they have adequate funds and access to loan facilities. The rate of change in plant growth and financial parameters were greater in private nurseries than government nurseries. Siddhartha Nursery, despite producing fewer seedlings, operates successfully by ensuring quality and reliability in its offerings. The determination and commitment of the nursery head plays a crucial role in the smooth functioning of private nurseries. For instance, K and K Enterprise's upgrade to the Agroforestry Resource Centre and their independent seed production showcase the potential for growth and improvement.

DFO nurseries are essential operations for producing a significant number of forest seedlings, contributing to biodiversity conservation. These well-supported nurseries hire caretakers and receive government budgets, ensuring their proper functioning and successful seedling production. The change in infrastructure facilities and production capacity is always higher in DFO nurseries. However, in the case of local government-supported nurseries, the lack of grant availability poses serious threats, leading to a shortage of funds. Unfortunately, this financial constraint has resulted in the collapse of the local government-supported nursery in Chaubas. The results suggest that the contributions of the different types of nurseries will all be important to ensure resilience in the supply of high-quality seedlings into the future.

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Annex 1: Standards and criteria for forest nursery accreditation

A. Standards for human resource requirement

Standards for human resource requirement is judged on the basis of individual skills/knowledge and experience on nursery operation and quality seedling production. Here four basic criteria are developed for evaluation of human resource involved in the nursery operation and management.

1. Nursery manager and/ or supervisor should have at least basic Diploma in forestry training to BSc or master in forestry level qualification and have one to two years of experience in nursery work supervision.

Criteria description	Points
Neither obtained academic degree nor any nursery related training	0
Not have academic degree but participated a nursery training from recognized institute with one year of experience in nursery work supervision	1
Not have academic degree but participated a nursery training from recognized institute with one year of experience in nursery work supervision.	2
Completed BSc forestry, nursery training from recognized institute & one year of experience in nursery work supervision	3

2. The nursery operator should have participated at least one nursery related training and should have working experience of at least three years for producing high quality seedlings

Criteria description	Points
Not received any nursery related training and no any working experience in seedling production	0
Have participated one nursery related training and one year working experience in forest nursery	1
Have participated one nursery related training and two years working experience in forest nursery	2
Have participated at least one nursery training and working experience of at least three years.	3

B. Standards for a basic nursery set up facilities and outlook

3. Infrastructure: nursery should have access to road/transport & market with enough space for tools/equipment storage, and facilities for electricity and fencing

Criteria description	Points
Nursery has space required for poly bag nursery but not for other facilities (only for nursery bed)	1
Have facility of water supply, road /transportation facilities (including above criteria)	2
Have enough facility of water supply, and space for equipment and tool storage (Have space for equipment and tool storage room including above)	3
Have reliable facility of water supply, equipment, electricity, fencing and market facilities(Have facilities of electricity, fencing, market, rest room including above criteria)	4

4. Facilities- There should be **the** presence of necessary nursery facilities such as seed bed, seedling bed and or hardening beds with soil sterilization and sieving facilities for quality seedling production

Criteria description	Points
Not having separate seed, seedlings and hardening beds	0
Have three types of basic beds (seed bed, transplant bed and hardening bed)	1
Have a soil, sand and compost sieving facilities including above facilities	2
Soil sterilization facility facilities including above facilities	3

5. Seedling container: nursery uses different sizes of polybags and hiko (elevated) trays for root training

Description	Points
Nursery uses makeshift materials (can, juice packs and plastic cups)	1
Nursery uses polybags	2
Nursery uses different sizes of polybags based on species requirements (duration-years, seedling size etc)	3
Nursery uses hiko trays (high density plastic used in forest nurseries) or elevated containers which is used for root training	4

6. Potting mixture: nursery uses forest top soils with drainage enhancers in the mixture

Description	Points
Pure clay soil	1
Clay soil with drainage enhancers (sand, leaf/forest peat, rice husk, saw dust) and fertilizer	2
Top soil from forests with high organic matter	3
Top forest soil with drainage enhancers and biochar use	4

7. General outlook of the nursery in terms of grading (according to the size of the polybags, age and type of the species) and cleanliness (weeding & hoeing) seems to be appropriate, attractive and appealing.

Description	Points
Nursery lacks appropriate grading and have poor sanitation	1
Nursery seedlings are graded based on species, age and sizes of poly pots	2
Have appropriate nursery seedling grading and good sanitation facilities	3
In addition to above nursery signboard is placed on a place that can be noticed easily from the outside	4

C. Standards for general quality seedling stocks

8. Sturdiness: seedlings should have robust stem

Criteria description	Points
All samples have sturdiness quotient value is of more than 10	1
10-16 samples have sturdiness quotient value is more than 6 but less than 10	2
5-9 samples have sturdiness quotient value is more than 6 but less than 10	3
< 5 samples have sturdiness quotient value is more than 6 but less than 10	4

Note: Sturdiness quotient: It refers to the ratio of the height of the seedling in cm to the root collar diameter in mm and expresses the vigour and robustness of the seedling. A small quotient indicates a sturdy and stouter plant with a higher expected chance of survival, especially on windy or dry sites (Jaenicke, 1999). A high ratio indicates a relatively spindly (thin) seedling (Haase, 2007). The ideal value for a seedling to be considered sturdy is less than six (Jaenicke, 1999 cited by Takoutsing et al., 2013). In the prevailing context of planting materials production in Nepal's forest nurseries, the sturdiness quotient of up to 10 or less is suggested for selecting nursery stock for planting.

9. Health: Seedlings should be free from pest & diseases, no mechanical or physical injuries and no stem rotting

Description	Points
All samples (16) are affected by pests and diseases, and but no mechanical injuries	1
10-15 samples are affected by pests and diseases, and no mechanical injuries	2
5-9 samples are affected by pests and diseases, and no mechanical or physical injuries	3
<5 samples are affected by pest and diseases, and or no mechanical or physical injuries	4

Note: Any plant or seedling is said to be healthy when it is free from pests and diseases, and at the same time, it should not have any mechanical injuries and physical damage.

10. Colour of foliage: The colour of leaves and foliage should be dark green/ green deep colour and no dark, pale-green foliage

Criteria description	Points
Almost all samples (>15) have pale green color foliage and leaves	1
10-15 samples (9) have pale green color foliage and leaves	2
5-9 samples (6) have pale green color foliage and leaves	3
< 5 samples have pale green color foliage and leaves	4

Note: Colour of foliage or leaves of seedlings is a general indicator of seedling quality and can vary by species and time of the season. Yellow, brown, or pale-green foliage indicates lower vigour than dark green foliage (haase, 2007).

11. Stem form: Good quality seedlings should have straight stem

Description	Points
All samples (>15) have two or more stem leaders and bent shoots	0
10-15 samples have two or more stem leaders and bent shoots	1
5-9 samples have two or more stem leaders and bent shoots	2
<5 samples have two or more stem leaders and bent shoots	3

Note: Any seedlings selected for planting in the field should have straight stem and a single stem leader

12. Root form: Quality seedlings should have well-developed root system and no evidences of root deformations

Criteria description	Points
All 16 samples have j-pot bound and curled roots and primary roots growing out from the container and penetrating into the ground	1
10-15 samples have j-pot bound and curled roots and primary roots growing out from the container and penetrating into the ground	2
5-9 samples have j-pot bound and curled roots and primary roots growing out from the container and penetrating into the ground	3
<5 samples have j-pot bound and curled root and primary roots growing out of container and penetrating into the ground	4

Note: The root system of plants can be assessed easily in bare-root seedlings and plants for stump production. A deformed root obstructs the uptake of water and nutrients from the soil and a bent or looped primary root does not provide a strong base for the anchorage of the growing plant (Harrison et al., 2008 cited by Takoutsing et al., 2013).