Assessment of seed and seedling supply system for forest plantation in Pakistan

March 2022

Assessment of seed and seedling supply system for forest plantation in Pakistan

March 2022

Authors

Dr. Zahoor Ahmad Bazai, z_bazai@yahoo.com
Dr. Stéphane Sciacca, stephane.sciacca@gmail.com
Munawar Khan Khattak, munawar.khattak@helvetas.org

Editors
Arjumand Nizami, arjumand.nizami@helvetas.org
Jawad Ali, jawad.ali@helvetas.org

Data support
Riaz Wagan, Chief Conservator Forests/REDD+ Focal Point, Forest Department Sindh
Syed Mujtaba Hussain, Conservator, Forest Department AJK
Irtaza Qureshi, Divisional Forest Officer/REDD+ Focal Point, Forest Department AJK
Niaz Khan Kakar, Conservator Forests/REDD+ Focal Point, Forest Department Balochistan
Syed Ali Imran, Conservator, Forest Department Balochistan
Gohar Ali, Divisional Forest Officer/REDD+ Focal Point, Forest Department KP
Iftikhar ul Hassan Farooqi, Director Forest Services Academy, Forest Department Punjab
Muhammad Essa, Divisional Forest Officer/REDD+ Focal Point, Forest Department GB
Raja Tariq, Provincial Coordinator Punjab (Helvetas)
Muhammad Bashir Khan, Provincial Coordinator Punjab (Helvetas)
Khalil Ahmad, Provincial Coordinator Punjab (Helvetas)
Sadiq Mughal, Provincial Coordinator Punjab (Helvetas)
Nadeem Bukhari, Provincial Coordinator Punjab (Helvetas)
Hamad Khalid Satti, hamad.satti@helvetas.org.pk
Zahid Rehman, zahid.rehman@helvetas.org
Sajid Hussain, sajid.husssain@helvetas.org.pk

Peer review
Syed Ghulam Qadir Shah
Parvez Mannan
Farhat Jabeen

Illustrations and formatting
Salman Fayyaz
Muhammad Riaz

Financed by
The Ministry of Climate Change, Govt. of Pakistan through REDD+ Readiness Package (R-Package) under Forest Carbon Partnership Facility (FCPF)

March 2022

Technical assistance
Helvetas Swiss Intercooperation

Table of Contents

List of Tables

List of Figures

ACKNOWLEDGEMENT

The authors acknowledge immense contribution from several actors in completing this important study at national level.

This report is the product of outstanding collaboration of forestry sector organisations, private sector players and experts on biological germ plasm production, particularly seed and seedlings production in forestry sector across all sub-national units in the country. The report assesses the current situation of public sector nurseries, nurseries raised by private businesses and communities, and seed collection system in the country. It also suggests strategy to improve quality control systems in seed collection to achieve a higher quality of seedlings and tree crops in the country. The study also assesses quantitative aspects of nursery production both in public and private sectors and suggests future course of action in strengthening seedling production system by the private sector.

The key message of the report is that the seed and seedling system needs appropriate quality standards acknowledged and practiced in all the sub national forestry departments in the country; and that the private seed and seedling production systems need to be supported for enhanced quality and quantity. The study concludes that it may be worthwhile for the Forest departments across country to assume a larger role or regulators of forest free germ plasm production and shift a larger production role to the private sector.

The study team may like to thank Forest Carbon Partnership Facility of the World Bank and National REDD+ Office (NRO) Ministry of Climate Change for initiating this important study. The team sincerely thanks NRO, Federal Seed Certification and Registration Department, private nursery growers and research institutions for their time and generous support including their contribution to provision of data necessary for completing this study. This document will serve a useful reference on several aspects of promoting high quality seed and seedling production in the country.

Authors and contributors

SUMMARY

This study assesses seed and seedling system in Pakistan taking data both from public and private sectors. For public sector nurseries, secondary data available with the forest departments of six sub-national entities was reviewed, relevant officials were interviewed, and sampled nurseries were physically visited. Data for private nurseries was collected through interviews with sampled 100 private nursery owners scattered throughout the country. Focus group discussion and key informant interviews were conducted. Data was collected using a questionnaire. Sampled nurseries were physically visited to observe nursery conditions and management.

This study presents findings on, quality, quantity, economics, tissues culture, seed system, and nurseries and contribution of the sector to employment. The study documents successes and challenges in seed and seedling sector and presents major findings and recommendation for improvement of the seed and seedling sector.

The study noted that the bulk of seed and seedlings are produced in the public sector (75%). The private sector nurseries mainly produce horticulture and ornamental plants in addition to small percentage of forest plants. This is because demand for forest plants is mainly fulfilled by the public sector. Demand for forest plants from the private nurseries is, therefore, low, and rather unpredictable. However, cost benefit comparison shows that the private nurseries are comparatively more competitive in terms of cost of production and also price than the government nurseries where cost of production is high when all factor of production are accounted for (including permanent and temporary staff, land, water, and administrative costs) indicating the need for encouraging the private sector to produce more forest plants instead of public sector producing costly plants. Major problems faced by the private nurseries in production of plants include unavailability of machinery and equipment, and training facilities. The private nurseries are also challenged by unpredictability of demand (lack of market information, demand forecast, lack of knowledge on priority species), lack of access to irrigation water and inability to find skilled labour.

A country wide survey of research facilities indicates that there are no tissue culture facilities for forest plants in the country. The sector could invest and take benefit of facilities available with the agriculture sector.

Forest seed supply system is poorly organized with low quality germ plasm resulting in poor quality progeny and tree crops. It is paramount that seed is considered an important foundation of high-quality tree production system in the country and standards are applied to determine the quality of seed used for nursery production. The forest sector could benefit from the legal mechanisms available with the Federal Seed Certification and Registration department for seed certification and quality control which is as relevant for forest plants as for agricultural varieties.

Chapter-1: Background and Introduction

Over 1.6 billion people around the world have a job or livelihood dependence on forests directly or indirectly, whereas 60 million indigenous people entirely and solely rely on the forest [1]. And approximately 350 million people living in vicinity or at the forest sites rely on forest resources for their income and survival. Furthermore, around 1.2 billion extreme poor people depend on forest resource for all or part of their livelihood. According to the Food and Agriculture Organisation (FAO) of the United Nations, the forestry sector contributes to Pakistan's national economy by creating employment opportunities and generating revenues. Around 68% of the country's population depends on firewood as a major sources of household energy and about 0.1 million people are involved in the fuelwood trade. In addition, more than 500,000 workers are employed by forest industries and about 80% of the people living in the rural areas depend on non-timber forest products to supplement their incomes[2].

Throughout the world, forests have faced degradation due to multiple factors. There is, however, a global realization among nations that reversing this trend is necessary for mitigating the effects and impact of global climate change. A diverse set of activities is needed to reverse forest degradation. Fulfilling large global promises for reclamation of degraded forestland require reforestation activities at multiple scales.

Encouraging regeneration (artificial and natural) is one of the key means to enhance forest base. A sustainable supply of healthy forest tree seeds, cuttings, seedlings, and other propagules is indispensable for success of reforestation and planting activities. Whatever the method, reforestation activities require good quality propagules to minimize chances of failure of seeds or planted material. The scarcity of good quality tree planting propagules is often identified as a major constraint in success of tree plantation campaigns. For the accomplishment of global commitments, a continuous and ample supply of seedlings and other propagules of standard quality are crucial. Furthermore, optimizing cost of tree germplasm and a sustainable supply system are equally important for easy access by local communities, and effectiveness of planting activities.

Pakistan is currently promoting REDD+ in the country. The Forest Carbon Partnership Facility (FCPF) of the World Bank has provided grant for several studies to strengthen REDD+ at national and sub-national level. This study titled 'Assessment of Seed and Seedling Supply System for forest plantation, including tissue culture and seed bank' is one of these studies.

The **main objective** of this study is to explore and assess seed & seedling supply system within public, private and not-for-profit[3] sectors in the county. The **specific objectives** are:

- To study and assess the current seed and seedling system in each of the provincial and territorial forest departments including tissue culture and seed banks
- To analyse the economic aspects of seed production and distribution
- To recommend concrete measures for effective seed and seedling supply system

1.1 Significance of topic for Pakistan

Pakistan has low forest cover and a high demand for wood products, therefore, there is a need to enhance tree cover within and outside the designated areas. As such, the availability of quality germ plasm is important to achieve a greater survival rate of plantations and production of quality timber. The quality of planting stock (*seeds, cuttings, or other propagules*) is a major factor in determining the success of tree plantation and reducing cost of germ plasm production. Moreover, failed nursery plants or seeds result in higher cost per unit of production. The survival of trees, growth performance, volume, and

[1] https://www.forestpeoples.org/sites/fpp/files/publication/2012/05/forest-peoples-numbers-across-world-final_0.pdf
[2] https://www.fao.org/3/am623e/am623e00.pdf
[3] For this study, we do not separately distinguish nurseries supported by NGOs sector. Community-owned nurseries may be either supported by NGOs or public sector actors, but they remain to be micro-businesses.

quality of timber that may be harvested from a plantation are greatly influenced by the quality of seed and seedlings used. Therefore, the seedlings raised in the nurseries need to be of a high quality.

During the past few years, seed and seedlings production has got a positive push due to high demand created by large scale afforestation programmes (namely for instance Billion Tree Afforestation Programme – BTAP and a follow up Ten Billion Tree Tsunami Programme – TBTTP). The focus of the provincial forest departments, however, has mostly been to meet afforestation targets and not necessarily on investing in quality of plants. There have not been any defined standards for propagation of plants and adoption of protocols for production of quality germ plasm. This opportunity, however, still exists since TBTTP is in its full swing and can take recommendations of this study for introducing quality protocols in seed and seedling production system both in public and private sectors.

In the Agriculture sector, seed multiplication, production, processing, storage, and marketing are dominated by the private sector with multiple layers of quality standards and seed certification and registration procedures. In case of forest propagules, however, no system of quality assurance and seed certification is practiced. Similarly, seedling production of forest tree has never required use of authentic or superior germ plasm. The forest departments and nursery owners are dependent mainly on the un-certified seeds or seed sources supplied by the local private suppliers or they choose to collect seeds directly from the forest through untrained labour.

There are no quick solutions to improve genetic quality of seedlings. Raising seedlings of high genetic quality requires the application of appropriate techniques for production of seedlings in the nursery. This includes selection of mother trees and collection of superior germplasm, proper storge and multiplication techniques. In addition, certification and registration systems are crucial for production of quality seed and seedlings in public and private sectors.

1.2 Framing components of the study

There are three types of nurseries commonly found in most countries, namely state or central nurseries, private nurseries, and community-based nurseries (group or individual farmers). Nurseries are also categorized as institutional (research, government and industrial) and project [4] based in relation to the objective of their establishment and continuity.

The study has assessed the following three aspects of seed and seedling production systems:

1. Present seedling production and supply system (public and private)
2. Present seed collection, storage, and supply system (public and private)
3. Relevance and usefulness of tissue culture for woody and non-woody forest plants

The main interest of the study is to assess the ***entire chain*** of germplasm production, maintenance, marketing, and distribution for planting in and outside forests (**Figure 1**).

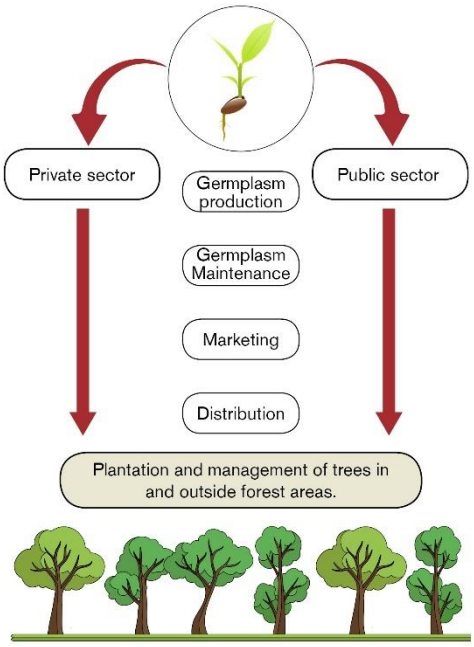

Figure 1: A generalized representation of Seed and Seedling distribution system

For data collection for this study, all the provincial Forest Departments of Pakistan, Forestry Research Institutions such as Pakistan Forest Institute (PFI) and Punjab Forestry Research Institute (PFRI) Gatwala, and seed collectors/nursery growers in the private sector were consulted. This report compiles results and provides recommendations for improving seed and seedling system in Pakistan.

[4] Roshetko et al. 2010

Chapter-2: Approach and Methodology for the Study

This report is an outcome of review of secondary literature, primary data collection, triangulation, and data analysis. Consultations were held with officials of several relevant and related organisations for data collection and expert opinion.

2.1 Secondary data

The literature reviewed included information available online as well as with the provincial forest departments, universities, research institutes, and international and national non-governmental organizations. A comprehensive review of literature from other countries was conducted to identify on going practices in seed and seedling production to understand applicability of these practices to Pakistan.

2.2 Primary data collection

For primary data, sampled public and private nurseries throughout the country were physically visited and onsite interviews were conducted with staff and owners of the nurseries. The study considered macroenvironment aspects (including economic, sociological, technological, environmental, and legal aspects) within which nurseries and propagules are produced.

The following organizations/ institutions were consulted for data collection and expert opinion.

- Pakistan Forest Institute (PFI), Genetic Research and Silviculture sections
- Agriculture Research Institute, Tarnab Peshawar (Tissue Culture Section)
- National Agriculture Research Council (NARC), BCI Institute and Rangeland Research Institute, Islamabad
- Nuclear Institute for Food and Agriculture (NIFA), Peshawar
- All six Provincial Forest Departments
- KP Forest department, R&D section
- Punjab Forest Research Institute (PFRI), Faisalabad Punjab
- Forestry Seed Centre Garhi Dopatta, Muzaffarabad AJK
- Haripur University, Khyber Pakhtunkhwa
- Management of Ten Billion Tree Tsunami Programme (TBTTP)
- Several public and private nurseries and seed dealers

This included nursery data and reports of all the six provincial forest departments including number and type of plants being produced in the nurseries, and seed procurement system.

Data on seed and seedlings managed by the public, private and community sectors was collected from all six provinces and Islamabad capital territory.

FGDs and KIIs: Staff of forest departments managing nurseries, and afforestation programmes, owners of private and community nurseries, seed suppliers, research institutions and forest development projects were interviewed. A total of 220 respondents were consulted for data collection and expert opinion (**Annex 1**).

Key informant interviews (KIIs) and Focus Group Discussions (FGD) were conducted by using a questionnaire as well as open ended questions. On-site field visits to selected nurseries in the main hubs allowed us to cross-check the data collected on supply system including types of plants grown, nursery raising techniques, target markets, volume of production, and quality of seed and seedling being produced. On-site field visits included nurseries managed by the public and private sectors and seed orchards. For data collection on private nurseries, a purposive random sampling through a cascade approach was adopted to overcome challenges (see section 2.2.2).

2.2.1 Public sector

Data collection for this sector was relatively easier since nurseries are limited in number, focused on production of forest seedlings, and easy to identify with the support of the forest department officials. Data on number of plants produced in the nurseries, type of species, plants distributed to others by the forest departments is, however, not systematically managed by the forest departments and thus challenging to collect. Following data sources were used:

- 88 key informants were interviewed which included:
  - Forest officials involved in the establishment of nurseries and distribution of seed & seedlings
  - Forest officials engaged in procurement of seed and seedlings
  - Officials of Research institutions involved in seed and seedling research
  - Forest official engaged in establishing or maintaining seed orchards
  - Forest development projects in public sector
- A total of 14 nurseries in six provinces and Islamabad were physically visited

2.2.2 Private and community-based Nurseries

There is no database on private and community-based nurseries in Pakistan. Most private nurseries grow mixed plants (ornamental, fruit, and forest) and, therefore, are not categorised as forest nurseries. These nurseries are scattered throughout the country. Locating and counting all the nurseries was challenging. To overcome this challenge, a cascade strategy was adopted for identifying and interviewing key respondents at main hubs in all six sub national entities. A total of 100 nurseries were physically visited and data was collected by interviewing 132 key informants (26 in Punjab, 22 in Sindh, 18 each in KP and AJK, 8 each in Balochistan and GB). To identify nurseries for physical examination, a purposive random sampling technique involving the following steps was followed:

- Main nursery hubs and key primary informants were identified with the help of provincial forest department officials responsible for procurement of plants and seeds from private sector.
- The key informants were interviewed to know further about main supply hubs and production and distribution system.
- Secondary key informants in these hubs/nurseries were interviewed for additional information. The secondary key informants identified tertiary key informants.
- The tertiary key informants were interviewed to deepen understanding regarding production and supply of seed and seedlings
- Through the above cascade strategy data was collected for most of the supply from private and community nurseries throughout the county.
- Presence of Nursery growers' associations were also traced, and their office bearers were interviewed and information from their websites was reviewed.
- Seed wholesalers and retailers were also consulted to explain the seed and seedling production chain's distribution and sales channels.

2.2.3 Data on economics of seed and seedling

Data were obtained from nursery owners/managers to conduct cost-benefit analysis. The data was then analysed in an excel based cost-benefit calculator (**Annex 2**) to learn about the following economic aspects of seed production and distribution:

- Is nursery an economically profitable business?
- Sale prices compared to production costs
- Margins of various players in the sector
- What is the sector's growth capacity (production costs, sale-price, employment)?

2.2.4 Quantitative and qualitative aspect of production

Data was also collected on qualitative and quantitative aspects of the plant production in nurseries. A few examples of question asked included:

- Do the nurseries have capacity to meet customers' demand?
- What is the supply and demand situation?
- Are nursery growers aware of the importance of quality of seeds and seedlings?
- What are the major obstacles in improving quality of seed and seedling?
- Availability of raw material for seed and seedling production and costs
- Availability of skilled labour

2.2.5 Refinement and validation

At the end of data collection, provincial consultative meetings were held to collect any missing data through triangulation and receive suggestions conclusions and recommendations. The draft findings of the study were presented to a consultative workshop held at PFI in November 2021 with participation from all provinces for validating data and acquiring suggestions to refine draft conclusions and recommendations.

Chapter-3: Practices in other South-Asian or Developed Countries

This chapter compiles literature review on international experiences on seed, seedling and propagules management including collection, production, supply, and distribution practices in other countries[5].

3.1 Seed collection systems

The tree germplasm supply systems consist of three major actors, namely the producers, distributors, and users. Tree seed production systems are characterized by the use of low-quality tree germplasm despite many recommendations to produce and grade tree seed to reflect its genetic worthiness to improve the productivity of woodlots, plantations, and agroforests. Tree germplasm is obtained from a variety of sources including seed stands, plantations, and seed orchards. In many countries in Africa and Asia, instead of collecting germplasm (seed) from seed zones based on geographic and climatic factors (elevation, latitude, and rainfall), collection takes place from most accessible trees without consideration quality of the trees and suitability for multiplication in different ecological zones. The result is reduced productivity of woodlots established using such germplasm.

The sources of tree germplasm are in most of cases a) farmlands, b) plantations and c) natural forests. In the Philippines 66% of the tree seed are collected from remnant trees on farms, 13% each from plantations and natural forests (Koffa and Roshetko (1999)). In Indonesia, 44% of seed is collected exclusively from plantations, 36% from farmland and 20% from both plantations and farmland (Roshetko and Mulawarman 2008). In Kenya, farmland is the most common source of tree germplasm, followed by plantations, natural forest, and seed orchards (Mbora and Lillesø 2007; Lillesø et al. 2011). Besides own seed collections, farmers also access germplasm through exchanges with neighbours, and buying or receiving it free of charge from NGOs, governments, and private companies. In general, in most of the countries in Asia and Africa, a system which better estimates the tree germplasm demand and supply for making informed decisions does not exist.

When collecting tree seed from natural forest for planting, a rule of thumb is to collect seed from at least 25 mother trees. Furthermore, to reduce the chance of collecting seed predominated by half-siblings, a 100m distance between seed trees is recommended (Dawson and Were 1997). For the same reason, there are also guidelines for collecting seed from farmland, plantations, and seed orchards (Mulawarman et al. 2003; Mbora and Lillesø 2007). These recommendations are, however, not followed. In a study covering 71 nurseries in East Africa, Lengkeek et al. (2004) found that for each tree species, seeds used in the nurseries were collected from a mean of only six mother trees. In 22% of the cases, the seed used in the nurseries was from single mother trees. Namoto and Likoswe (2007) surveyed 43 nurseries in Malawi and found that most nursery operators collected seed from between one and 26 mother trees, with a mean of just over four mother trees per nursery. Koffa and Roshetko (1999) found that 60% of farmer seed specialists in Lantapan in the Philippines collected seed from only 1 to 5 trees. These same farmers were also observed to collect germplasm without consideration to the phenotypic appearance of the trees (Cacanindin 2010). To overcome these challenges, Mulawarman et al. (2003), Lengkeek et al. (2004) suggested establishing local nursery or seed collector networks, through which germplasm could be mixed and exchanged as a way of increasing the genetic diversity within species.

For example, Nepal developed a tree planting zones system where planting sites with similar environmental conditions are grouped together into zones (in some cases the same tree planting zone might appear physically separate) for which specific seed sources can be developed and thereby increase farmers planting success. The 'tree planting zones' can be recognised in the field by farmers and will be utilised where the greatest potential for seed demand lies. The system of 'Tree Planting Zones' will be part of a tree seed distribution system that will contribute to the improvement of the living conditions for the poor farmers (smallholders) in Nepal. The farmers demand for fodder and fruit tree species in Nepal is of many species in small quantities, and the demand is therefore best fulfilled through a decentralised

[5] NYOKA et. Al. (2014) Tree Seed and Seedling Supply Systems: A Review of the Asia, Africa, and Latin America Models.

distribution carried out by farmer associations, seed cooperatives and private suppliers. In the short term the demand will have to be fulfilled by collection from trees occurring on the farmers' fields, while in the longer term the genetic potential of the species can be released through establishment of simple and intermediate breeding seed orchards (Dhakal, L.P. et al. 2005).

3.2 Seedling production systems

Typology of Nurseries: Tree nurseries are an integral part of a germplasm supply system for tree species that are established from seedlings. There are four main nursery's types that are commonly found in most countries: (i) state managed or central nurseries, (ii) private nurseries, (iii) community or farmer group nurseries and (iv) individual farmer nurseries.

There is no consensus over which nursery type is ideal. The advantages offered by group nurseries include environment for learning in groups, exchange of ideas and dissemination of information among the farmers, improved access to extension services, improved and less expensive service provision (Garcia 2002; TLC 2006). Group nurseries have, however, additional transaction costs on group organization at the expense of productivity (Böhringer et al. 2003). Lack of coordination and poor nursery management are the main disadvantages of farmer group nurseries (**Table 1**).

Table 1: Nursery sizes as number of seedlings produced annually in selected countries.

Country	Nursery type					Range of species in nurseries
	Central nurseries	Group nurseries	Individual farmer	Private commercial	Others[a]	
Malawi[1]	30,000-90,000	1.852-12.181	583-3.352	10,000-200,000	na	1-19
Uganda[2]	38,000	60-24,100	355-25,000	27,000-175,800	na	1-28
Indonesia[3]	20,000-1,000,000	10,000-20,000	100-50,000	10,000-800,000	na	1-30
Philippines[4]	164,000	21,000	21,000	334,000	5.000	13
Vietnam[5]	10,000-1,500.000	25,000	15,000-1,500,000	750,000-1,500,000	na	1-10
China[6]	800,000	566,000	170,000	Na	na	17
Kenya[7]	na	140-20,000	1,000-500,000	Na	400-6,000	1-19
Mali[8]	1,000-5,000	300-2,000	100-1,000	10,000-50,000	na	1-25

[a] Nurseries of educational institutions; *na* not available

Source [1] Mvula and Lilleso (2007), Namoto and Likoswe (2007); [2] Asare and Pedersen (2004); [3] Purnomosidhi and Roshetko (2012); [4] Mercado and Duque-Pirion (2008); [5] Johansen et al. (2011); [6] He et al. (2012); [7] Muriuki and Jaenicke (2001); [8] ICRAF-WCA/Sahel, unpublished data)

Challenges in seedling production and Policy support: Adequacy of government policies is a critical factor in germplasm supply systems. Place and Kindt (1997) observed weaknesses in policies on tree germplasm supply in sub-Saharan countries which include fragmentation of institutional mandates and functions, lack of coordination of planning, lack of information on germplasm demand for different species, and the poor and unstable funding environment of institutions involved in germplasm supply and utilization. For example, in southeast and east Asia, Harrison et al. (2008a) found that government policies tended to favour quantity over quality of the seedlings produced thus leaving poor standards in quality of seeds. Farmer nurseries were set up to provide seedlings to support government afforestation programs in some Asian countries but many ceased operating with the termination of government tree planting activities because they lacked resources and were dependent on government contracts. The challenge of most nurseries closing after the end of projects has also been observed in Southern Africa (TLC 2006; Matenda et al. 2010).

Most nursery operators face similar challenges in both Asia and Africa which include lack of market, low seed quality and inadequate funds. Harrison et al. (2008a) cited a number of initiatives and policies that governments can use to improve seedling production and financial viability of small-scale nursery

operators in Southeast Asia. They include improving access to resources such as up to-date information, new and affordable technologies, availability and access to high quality germplasm, and skills in nursery management as well as financial management. They further pointed out that where smallholder farmers with low income form the bulk of the market, seedling producers should achieve low seedling prices by using appropriate low-cost production systems and tapping in on particular high-value tree species such as fruit trees.

Viability of nursery size: Although nursery sizes vary across countries and ownership, Herbohn et al. (2011) indicated that a nursery producing 6,000 seedlings or more per annum could allow the operator to break even. An optimal nursery size that could provide livelihood benefits is one producing about 25,000 seedlings per annum. Very small nurseries would incur high seedling production costs and would probably not justify the expenditure required for durable infrastructure and certified seedling production (Herbohn et al. 2011). Besides these studies in Asia, there appears to be limited information on nursery viability sizes in the other countries in Africa and Latin America (**Table 2**).

Table 2: Major constraints experienced by nurseries operators in selected countries

Constraints	Burkina Faso	Malawi, Zambia, Tanzania	Kenya, India	Philippines	Indonesia	Mali
Overgrown seedlings				✓		✓
Lack of market	✓	✓	✓	✓	✓	✓
Animal damage	✓	✓	✓	✓		✓
Lack of adequate funds	✓			✓	✓	✓
Lack of water	✓	✓	✓		✓	✓
Lack of seed	✓	✓	✓		✓	✓
Lack of seed of desired species			✓	✓		✓
Lack of training and information	✓	✓	✓	✓	✓	✓
Pests	✓	✓	✓		✓	
Shortage of labour	✓	✓	✓	✓	✓	
Lack of nursery space		✓	✓			
Lack of transport for seedlings	✓		✓			
Low seed germination			✓	✓		✓
Pilfering				✓		
Market competition				✓	✓	✓
Source: Bohringer and Ayuk (2003); Raebild et al. (2005); Shisanya et al. (2007); Geogorio et al. (2008); Mercado and Duque-Pinon (2008); Harrison et al. (2008a); Gregorio et al. (2010a)						

In China, after the decentralization of nursery management from the late 1970s, the state, collective and individual nurseries have operated differently with fluctuating production. Technology, infrastructure, and market competition are the key factors that influence production capacity. The state nurseries produce the greatest amount of tree seedlings with limited nursery size, followed by the collective nurseries, while the individual nurseries being constrained by technology and infrastructure that reduces their competitiveness in production. It is commonly found that state and collective nurseries are operated and managed by well-trained staff, most of whom have more than 10 years' experience; moreover, these nurseries are equipped with greenhouse facilities with overhead irrigation systems, seedling pricking and hardening facilities, as well as connections with irrigation and shelter for germinated seedlings (He, et al. 2011).

3.3 Seed and seedling supply systems

One of the challenges faced by national seed centres that were established in many African countries was their inability to reach many farmers as a result of their central location (Aalbæk 1997; Koskela et al. 2010). It is estimated that these seed centres deliver less than 10% of the farmers' tree seed demands (Graudal and Lillesø 2007). In most countries, smallholder farmers are widely dispersed, making the distribution process expensive. Besides government agencies, NGOs play a major part in germplasm distribution in many countries. Although their penetration is better than governments, they are not

sustainable as their presence is often erratic. Cambodia's tree seed supply and distribution system draws on the strengths of village seed supply systems, and private and central government partnership. The communities manage seed sources and collect and sell seeds; the private sector links the seed communities to users through the market; and the government's Forestry Administration provides the relevant legal framework and certification role (CTSP 2003; CTSP 2004). China has both private sector and state germplasm supply systems (He et al. 2012). Although smaller than the government supply, individuals and farmer groups sell their germplasm directly to farmers without going through middlemen. Nurseries are certified for quality by the forestry department like in Indonesia, demand for tree germplasm in China is driven by the government's large afforestation and reforestation programs. State nurseries do not appear to crowd out the private players because they focus on tree species that are used in government afforestation and reforestation programs, while private nurseries focus on high value tree species, including fruit, nuts, edible oils, fodder, and rubber (He et al. 2012).

The overall development of seedling supply system in China has undergone a transformation from a centralized system to more decentralized management, along with social and political changes. Prior to 1978, the nurseries were owned either by the state or by collectives (communes) that relied heavily on government subsidies, the government being the only customers buying seedlings. This central planning and command system for nursery management had restricted the alternatives seedling sources and improvement of the seedling production system. The centralized production and distribution system resulted in low quality germplasm and a limited range of species. In the commune system and collectivization of land use and production, the farmers had little incentive and interest in afforestation aside from complying with the state authorities (He et al. 2011).

From the late 1970s, the Chinese government opened its markets and reformed the political administrative system to solve food shortages and promote economic development. The decentralization reform has enabled the engagement of various forms of nurseries and created a hybrid system of state nursery operations, owned by the state but operated by individual contractors. This system has provided much needed support for smallholder access to high quality planting materials and improved the effectiveness of nursery management. However, the monopoly of state nurseries as the major seedling supply system using its inherent technical, market, policy and institutional advantages has limited the development of small-scale nurseries. This reform has improved the tree nursery operations and the development of the various types of nurseries. By introducing market mechanisms and devolving management control, the reform has overcome the problems of the centralized tree seedling productions system, such as overreliance on state subsidies, low seedling quality and low nursery profitability. With the diversification of the nursery types, the state nurseries continue to play a central role in providing high quality planting materials for the development of small-scale forestry. This is because state-sponsored afforestation is still one of the major forestry activities and is the biggest investment for tree planting in mountainous regions. Thus, to improve cost-effectiveness, the Chinese government has created a hybrid system for state nursery operations that has decentralized their operations but remains centralized in meeting its production goals. The market mechanism in the state nursery operation has shifted the government's role from producer and buyer to a single role as buyer. As a result, the government now exhibits more concern about quality and price rather than quantity and concentrates its attention on monitoring of quality and development of new species (He et al. 2011).

In contrast to positive aspects of this hybrid system where nursery operations are decentralized but production goals are centralized, this system imposes technological and institutional constraints to the development of other forms of nurseries. In particularly, the certification scheme restricts small-scale nursery operators from becoming engaged in formal seedling production and marketing; small-scale operators have to tie-up with the state nurseries. Moreover, the hybrid system provides greater opportunity for state nurseries to monopolize the bidding of seedling production for state afforestation, which limits the participation of other nurseries. This institutional arrangement has restricted the effectiveness of tree seedling production. At an operational level, there is a clear need for supporting further meaningful decentralization in nursery development that will help to reflect the diverse needs of farmers in terms of species and technology (He et al. 2011).

Chapter-4: Seed production system in Pakistan

In Pakistan, the Federal Seed (Amendment) Act, 2015 (clause 12)[6] defines seed "*any of the branded reproductive or vegetative propagating material of the plants of field crops, vegetables crops, fruits, spices, medicinal herbs, flowers, shrubs, forest trees, other species and mushroom spawn used for sowing or planting the genera or species prescribed by the Federal Government".* This definition covers forest trees and thus in the absence of any specific frame condition for forest seeds, this law gives policy space for development of forest seeds industry. As per law, there are three categories of seed in agriculture:

- ***Pre-basic seed:*** *The initial seeds obtained from selected individual plants of a particular variety, for the purposes of purifying and maintaining that variety for its further multiplication under the supervision of a qualified plant breeder, to provide the basis for all further seed production.*
- ***Basic seed:*** *Also known as foundation seed, it is the descendent of breeder seed and is produced under conditions that ensure maintaining genetic purity and identity. Basic seed is used to produce the certified seed.*
- ***Certified seed:*** *Seed of good quality and established identity verified by seed certification agency or department.*

Seed certification is the process by which a state seed certifying agency gives official recognition to seeds produced of a cultivar or named variety under a limited generation system which ensures genetic purity, identity, and a given minimum level of quality. Recognized classes of certified seed include Breeders Seed, Foundation Seed, Registered Seed, and Certified Seed. "Certified seed may be defined as that seed where all procedures are followed like breeder, ecologist, time of seed collection is known, type and tree population are known, proper germination tests are carried before sowing in the nursery".

In Pakistan, Federal Seed Certification and Registration Department provides quality control cover through registration of crop variety, crop inspection and seed testing. This system is being implemented at federal level under the Seed Act, 1976 and Seed Amendment Act, 2015. However, the practice of using certified seed for raising nursery in forestry sector are not followed in Pakistan.

In addition to the above, the law also defines *Genes Bank as biorepository which preserve genetic material. For plants, this is done by storing seed, freezing cuttings from the plant, or stocking the seeds.* In comparison, seed categories in forestry include the following:

- ***Unclassified seed*** *– seed collected from unknown sources (unknown about the seed source/ origin etc. and used for raising nursery seedlings for propagation.*
- ***Classified seed*** *– seed from known location and plant species. Generally, the local forest department or suppliers collect seed from the source and use for raising nursery seedlings.*
- ***Certified seed*** *– seed which is produced by following all breeding principles including collection of seed from known species and tree characteristics and population, time of seed collection, proper germination tests carried out before sowing etc. However, the use of certified seed for raising forest nurseries in Pakistan does not exist.*

Seed Orchards: There are two main types of seed orchards, named according to the way these are established:

1. ***Clonal seed orchard****: Seed orchard raised from selected clones propagated by grafting, cutting, air-layering or tissue culture.*
2. ***Seedling seed orchard****: Seed orchard raised from seedlings produced from selected parents through natural or controlled pollination.*

[6] https://sap.com.pk/pdf/resource-center/The-Seed-Amendment-Act-2015.pdf

Seed orchards or germplasms are stands planted or set aside especially, to produce abundant superior/ good quality seed. *Comparable to gene banks in agriculture, a seed orchard is an intensively managed plantation of specifically arranged/ identified trees for the mass production of genetically improved seeds to create plants, or seeds for the establishment of new forests. Seed orchards are stands planted specially to produce abundant superior seeds. A seed orchard consists of trees where the phenotype is usually of minor importance as long as the trees will produce healthy seeds.*

4.1 Maintenance of Germplasm/Seed Orchards

In the past when forest management was exclusively guided by working plans, the staff used to manage the seeds as per requirement in the working plan and public demand. This demand was ascertained based on previous years' demand for seeds. The seed was usually collected from good quality stands by engaging daily labour. Seed used to be fresh with good viability and genetic source. After the working plan was practically abolished, there were no certainty of targets for the next years or seasons. Some of the approved schemes were abruptly discontinued which had implications for the seed collected and maintenance of seed orchards.

Currently, when required, the seed is purchased from local seed sellers in various towns. These sellers are usually not primary collectors. They engage labour or purchase seed from villagers who collect seed from nearby tree stands. This, however, is a very small and erratic business opportunity, therefor, no formal permanent market and quality protocols exist for tree seeds.

Quality of seed is usually poor, genetic source is unknown, and supply is not guaranteed. The choice of species is very limited. Only seed of selected species such as, *Dalbergia sissoo* (Shisham), *Acacia nilotica* (Kikar), *Acacia modesta* (Phulai), *Albizia lebbeck* (Black Siris), *Melia azedarach* (Bakain), *Eucalyptus camaldulensis* (lachi), *Bombax ceiba* (Simal), *Ziziphus mauritiana* (Beri), *Pinus roxburghii* (Chir pine), *Pinus wallichiana* (Kail), *and Aesculus indica* (Ban Akhor). Good quality seed is available in limited quantities. There is no scientific system of seed quality testing at the time of seed purchase. Seed quality is randomly checked manually. There are no written rules for quality of seed and viability and thus good practices are not consistent and mandatory. In practice, viability above 80% is required for a successful nursery establishment. Theoretically, payments are made to the vendors after conducting viability tests. Viability test results are usually required to be attached for sanction of bill of price of seed. Although not on a very systematic basis, the department conducts viability test of seeds purchased before supplying seeds to the nurseries for sowing.

There are few seed orchards from a 1996-2001 initiative under a provincial project. However, these are hardly able to meet the demand of even one forest division. Seed certification system for forest species does not exist in Punjab. Plus, trees have been marked based on phenotypic characteristics throughout Punjab and are recommended for seed collection, but these may hardly meet the demand of even a single forest division. Due to non-availability of quality genetic material the quality of plants produced is highly compromised and their genetic source is unknown, consequentially tree crops may lead to genetic degradation.

The Genetic Research Section of Pakistan Forest Institute (PFI) is responsible for conducting research on forest plants/ species. The research activities have nearly stopped due to lack of scientists, equipment and financial resources after the 18th constitutional amendment and devolution of PFI to the province. The genetics section does not have allied facilities such as functional seed storage. The existing storage is currently non-functional due to unavailability of financial resources. Similarly, the seed orchards established by PFI in different parts of the country, especially in south, are not maintained by the institute for the same reasons as explained before. PFI has raised a small mother plants garden with different species at PFI botanical garden, from where seed is collected for its own nursery.

The Silviculture section of PFI is producing nursey of selected species from the seed supplied by the genetic section at PFI. This, however, is not a real-life situation on ground. According to the Director Silviculture, the role of genetics section is to collect seed from different sources and provide to

silviculture section for further multiplication. Silviculture section does not collect seed on large scale. With limited resources, the nursery at PFI is raised with only 25000 – 40000 plants of different species. Similarly, the range management section is growing its own nursery mainly of grasses and shrubs. The silviculture section of PFI is carrying research trials on different plants species on pilot basis. Once succeeded, they handover planting material to the provincial Forest department for further multiplication through large-scale plantation. One such example in recent past is *Acacia albida* which was multiplied with the help of PFI.

The Research and Development (R&D) directorate of KP Forest department has identified seed stands in each ecological zone. These constitute a group of trees demonstrating best phenological characteristics in a given ecological zone for a given species. All the seed stands have been properly demarcated. However, the directorate has no management control over the areas and haven not been handed over to the directorate. Once notified, all types of seed collection activities from these stands will cease except by the R&D Directorate.

The **Punjab Forestry Research Institute Gatwala** is the only forest research facility in Punjab. The research institute does not have facilities on genetic material development and testing. The Punjab Forest department initiated the efforts to establish seed and seed supply system in Punjab under a project "Punjab Forestry Sector Development Project" during 1996-2001 at PFRI. During the project period, several studies and reports were prepared about the seed supply system, however these were not readily available. Under PFSD project, a list of seed stands and plus trees was also established in Punjab. This list is now lost in old records and is not readily available with the department. In any case it was too long ago when these plus trees were identified and even with the list available, the trees may have been deteriorated. Research work in forestry sector has nearly stopped due to resource constraint and low priority for research.

Previously there was training facility at PFRI on seed and seedling quality management. After the establishment of Punjab Forest Service Academy in Murree, this service has been shifted from Gatwala to Murree. A training need assessment is being conducted and such trainings are likely to be resumed and scheduled shortly at the Services Academy. In Punjab, seed arboretums having different species were established by Pakistan Forest Institute and Punjab Forest department in Changa Manga, Chicha Watni and Rakh Dagar Kotli for the purpose of quality seed collection. However, currently the department buys seed from private seed dealers/collectors through an open tender. The quality of seed provided by these private suppliers is very poor.

In **AJK, a Forestry Seed Centre** was established in 1990-91 under the project "Integrated Hill Forest" with financial assistance of the World Bank. The overall objectives of establishing the seed centre are to produce quality, certified seed of forest trees and to ensure the continuous supply of seed to the forestry sector in AJK on a reasonable price. Few seed stands have been identified by the centres. They also maintain a list of plus trees. The centre AJK supplies seed to different forest divisions based on their demand before the nursery establishment season. The only figure available from 2018 was a supply of 24-ton seed of different species to AJK Forest department. The seed centre operates on supply driven approach and does not have capacity to operate according to demand. The centre was severely damaged by 1992 floods, 2005 earthquake and 2010 floods. Currently, the forestry seed centre AJK is partly functional with extremely limited human and financial resources with a manager supported by Range Forest Officer, two Foresters and four Forest Guards and support staff.

The Forestry Seed Centre AJK collects seed from the identified and marked plus tress in seed stands of different species through engaging private seed collectors. The forestry centre before paying for the seed from the collectors, clean the seed and conduct purity, germination, and viability tests. It is then tagged and provided to the department during the season. The following information are placed on tag before supplying to the department.

- Name of species
- Germination percentage

- Viability of seed
- Location (place of collection)
- Year of collection
- Purity (percentage of inert material) etc.

Seed production is a major issue **in Balochistan** due to very low rainfall. In Balochistan, no seed collection and storage system exist in the department with the exception of very limited seed stores mostly to cater the needs of ornamental or horticultural plants. Seed collection target of forest species is met by assigning forest guard and game watchers. Seeds are stored in makeshift places on *ad hoc* basis. Seeds are collected from trees with better phenotypic characters but there is no way to monitor this.

In case of Sindh too, forest seed collection system is informal. *Acacia nilotica* (Babul) seed is the main requirement of riverine and irrigated forests of Sindh, especially during inundation season. Babul seed is mainly procured from private seed markets existing in Sanghar and Hyderabad districts. The seed is also collected by the department staff directly from the irrigated plantations and riverine forest stands. Breaking seed dormancy is essential in case of hard coated seed of Babul. This is done through an age-old practice of feeding seed pods to goats to obtain viable and ready to sow seed from faeces of goats. Seeds of Conocarpus, Eucalyptus, Neem and other species are obtained from mother trees standing in the vicinity of nurseries. The seed of ornamental plants and fruit species is purchased from private nurseries in Karachi, Hyderabad, Mirpur Khas, and other major cities.

In the Mangrove forests, *Avicennia marina* is the predominant specie (90%) in coastal region with *Rhizophora mucronata* (8%), *Aegiceras corniculatum* (1.5%) and *Ceriops tagal* (0.5%). Pure mature stands of Avicennia and Rhizophora are found in different creeks and are protected through watch and ward system of local communities. The seed / propagules are collected on regular basis from identified locations in Port Qasim area of Karachi and Keti Bundar areas.

There are about 30 to 40 famous seed dealers in Sindh province in the private sector who deal with the collection and marketing of seed and feed public nurseries. The quality of babul seed is physically checked by putting a measured quantity of seed into water. The estimate of unviable seed is calculated from the percentage of seed floating on top of the water, whereas the viable and healthy seed being heavier submerges in the bottom. There are no seed orchards in the province as such. The pure and mature stands of Avicenna, Rhizophora and Acacia in a way serve as seed orchards. The seeds procured from open market are certified by the filed officers for viability by checking physical characteristics. There is no laboratory to check seeds quality. No formal training on seed testing is imparted to the field officers.

4.2 Seed collection for nursery production

4.2.1 Public sector

Quality seed is a prerequisite for raising good nurseries to get healthy and standard quality planting stock which would result in good forest cover having optimum yield. There is no proper system of certified seed or quality planting stock production anywhere in the country. Generally, seed is purchased from the local seed suppliers in various locations/sites and used for nursey raising. These specific suppliers buy seed from local seed collectors (forest dwellers) who collect seed from accessible locations anywhere within the forest. There is no proper market from where seeds of forest species are available on a competitive basis. Thus, practically, either the Forest departments' field staff collects seed from natural forests or purchases from the private seed suppliers or collectors for raising nurseries. Purchasing is often organized through inviting tenders for high value tree species or the species for which large quantity seeds are required. An alternative system for smaller quantities is to engage seed collectors or labourers paid through muster rolls. The seed supply system was not institutionalized by any Forest department in the country due to the reasons that there has not been a consensus if a separate seed supply system set up is necessary for forest management activities. The Forest departments everywhere in the country feel

constrained on seed issue and feel the need for a separate wing dedicated to high quality seed production and supply to fulfil the departmental demand.

4.2.2 Private sector

Multiple seed sources[7] are used by private nursery owners for raising nurseries (**Figure 2**). A dominant number of nursery owners in GB and Balochistan collect their own seed or propagules from trees accessible to them in the forests or other sources and supplement with purchases. In AJK and KP, majority of nursery owners use their own stocks and buy seeds from the market. Sindh and Punjab have tendency to use multiple sources (own, bought and collected seeds). The data show significance of seed collectors who sell seed to the nursery owners. Investing in quality assurance in their seed supplies may lead to better quality of nursery plants and crops.

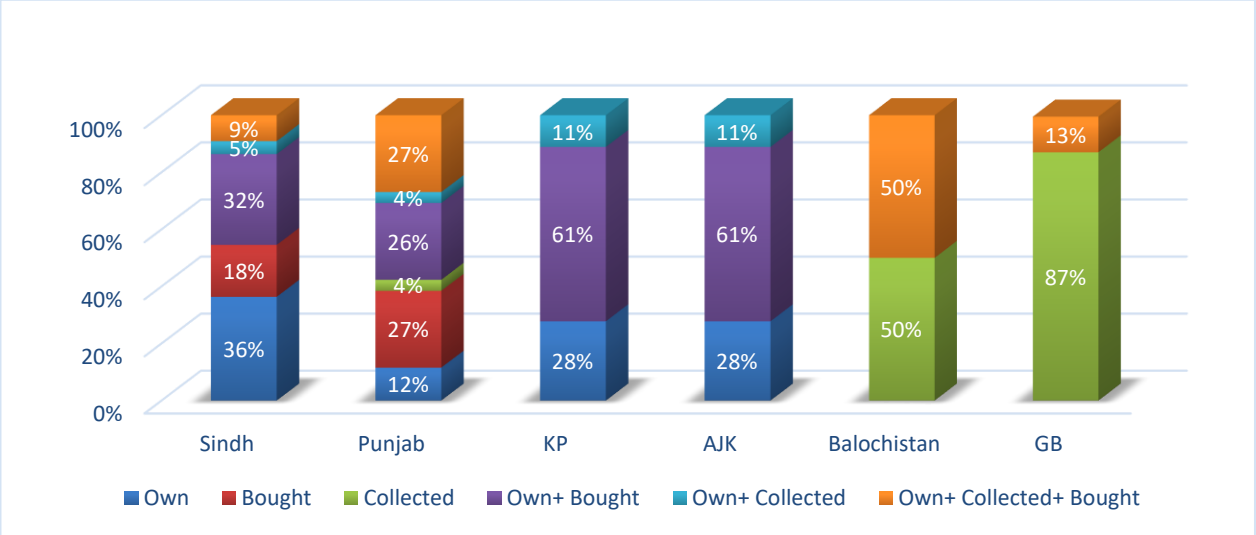

Figure 2: Seed sources used in sub national Forest departments

Overall, 75% collection is made from plus or genetically superior trees and 25% seed is collected from random trees that are not specifically assigned for seed collection. In case of Sindh 77%, Punjab 77%, KP 83%, AJK 83%, Balochistan 50% and in GB 50% seed is reportedly collected from plus trees (**Figure 3**). It is important to note that the trees indicated by the nursery owners are in plus category from their own definition. Trees demonstrating better growth and phenological characters are plus trees for them. 100% respondents reported lack of knowledge regarding any seed orchard or seed banks managed by the department.

[7] Sources refer to multiple categories. Own source refers to the trees owned and maintained by nursery owners as a supply of germ plasm for the nurseries; collected refer to the seed collected by labour engaged by nursery owners to collect seed from forest trees; bought or purchased refers to the seed purchased from multiple collectors who collect seed from random trees for the purpose of selling to the public or private nurseries.

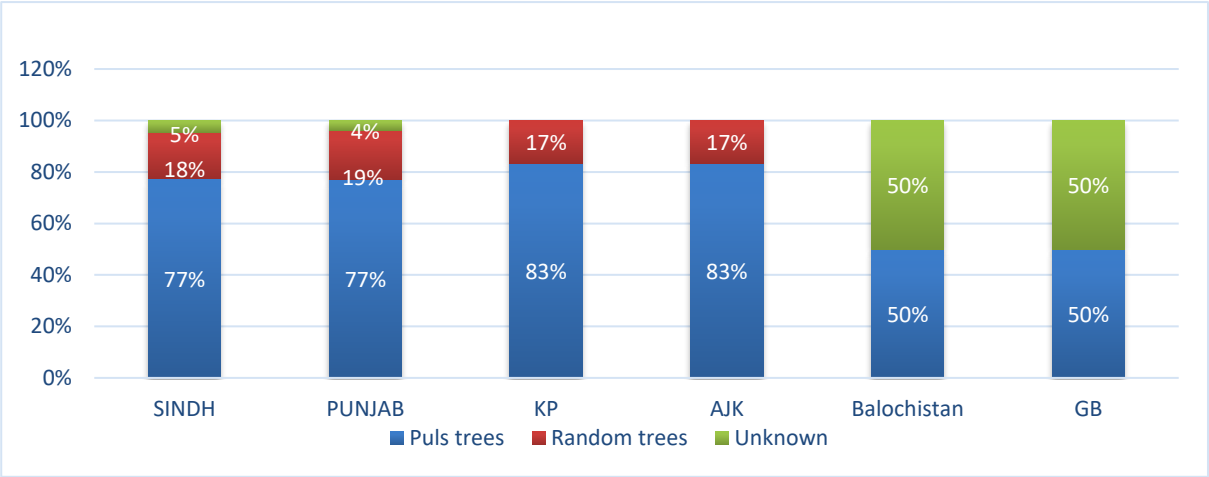

Figure 3: Origin of Seed

Origin of seed available for purchase includes gardeners *(malees)*, private seed stores and forest departments. Overall, 64% seed is purchased from private seed stores, 34% from gardeners or independent vendors and a very minor (2%) from Forest department. The trends vary among provinces. In Sindh, 38% of seed is purchased from the gardeners whereas 62% of seed is purchased from private seed stores. In Punjab, 76% seed is procured from seed stores. Punjab is the only province where forest department is indicated as a source of seed. In KP and AJK, a larger dependence is on private seed stores (64% and 73% respectively). In Balochistan and GB 100% seed is purchased from gardeners (**Figure 4**). The respondents were asked if the quality of seed from purchased source was satisfactory; 94% respondents were satisfied with the seed quality whereas only 6% had concerns. Those who were satisfied, had limited understanding of the means and standards for quality assurance of seed purchased.

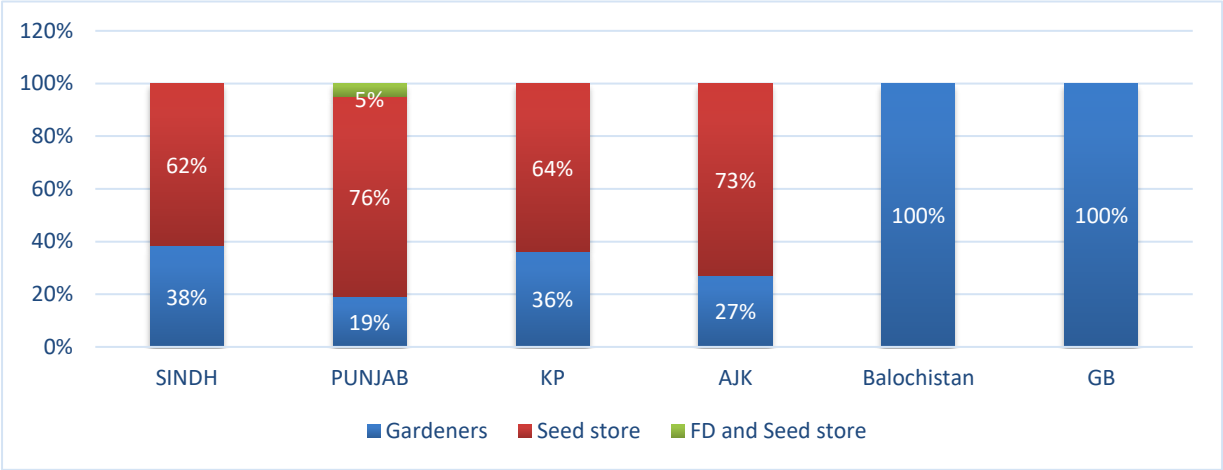

Figure 4: Sources of Seed Purchase

4.3 Seed testing Facilities

Under clause 22-F of FSCRD seed Act 2015 amendment, establishment of seed testing laboratory within the auspices of Forestry sector is legally justified: "*The Federal Government may, by notification in the official Gazette, allow accredited seed laboratories in the public and private sectors to carry out analysis of seed of any kind or plant variety or hybrid under this Act in such manner as may be prescribed".*

All the forest officers interviewed for the study suggested that the seed procured from private seed suppliers is checked by physically examining the samples of the seed to be purchased. Currently, Forest departments in all provinces including AJK & GB lack both storage and testing facilities for forest seed. There is no established seed testing laboratory for forest seed in any public or private set up. One such

lab was reportedly established by KP R&D directorate in 2015, but it is not functional and has no appropriate equipment. The R&D directorate has developed initial parameters of seed testing. They intend to establish seed testing labs in different ecological zones of KP. They are launching a project for initiating seed certification process. Seed storages are proposed in the project in the natural environments.

4.4 Seed certification protocols of forest plants

Federal Seed Certification & Registration Department (FSCRD) as a government seed certifying agency gives official recognition to seeds produced of a plant/ specie under a limited generation system which ensures genetic purity, identity, and a given minimum level of quality. The forest plants seed, and seedling certification protocols/ standard production procedures is available, "Forest Tree Seed Certification Standards, 1988" (**Annex 3**) but these were not finalized, approved, and applied in the field due to the reason that no such supply system exists in public or private sector.

The certified seed and seedling production procedure exists but practically it is not followed in the field as no seed supply system is established in the country. Similarly, segregated roles to be played by the different actors in seed and seedling supply chain such as PFI (Silviculture and Genetic sections), R&D directorate of KP forest department, PFRI in Punjab, Forestry Seed Centre AJK and private nursery growers are still not clear and needs to be defined properly. An example is provided in **Table 3**.

Table 3: Potential roles of different stakeholders in the germplasm production and supply chain

Activity	Actors			
	Farmers	**Private**	**Public sector**	**NGOs**
• Develop enabling regulation on germplasm quality			X	
• Develop seed sources map		X	X	
• Seed Collection	X	X	X	X
• Establish seed sources	X	X	X	X
• Seedling production	X	X	X	
• Quality control – compulsory		X	X	
• Quality control – voluntary	X	X		
• Germplasm Distribution	X	X	X	X
• Strategic seed reserves		X	X	
• Germplasm Conservation and Maintenance	X	X	X	
• Import /intensive test of tree germplasm for adaptation		X	X	
• Test tree germplasm for local (non-intensive) conditions	X			X

Source Adapted from Lille's et al. (2011).

A draft protocol for forest seed orchards, seed collection and quality assurance has been prepared for the policy makers' consideration. The draft went through several provincial and national consultations and was refined with multiple inputs, including those from Pakistan Forest institute, National Agriculture Research Centre, Pakistan Forestry Research Institute and Federal Seeds Certification and Registration department. The draft is attached as **Annex 4**.

4.5 Coordination among different stakeholders

There is no interprovincial coordinator to organize demand, supply, and research on seed issues. Ideally, PFI could serve as a parent certified germplasm bank (progeny or seed orchards) from where all the forest departments and private growers could collect multiplication material. There may be a defined segregated role for PFI, forest departments, private nurseries growers, tissue culture facilities in seed and seedling production system in the provinces. This functional coordination will also create opportunity to carry out joint research activities. Similarly, the coordination with other organization such as National Agriculture Research Centre (NARC) and forestry-based research facilities is also very weak, and needs be established based on clear expectations and roles.

4.6 Research & Development

Research & development has never been the core function of provincial forest departments. Their main focus has been on planting and harvesting the forest trees. Therefore, there is a limited drive and allocation of resources for public sector research institutes to invest in seed technology of forest trees since there is no formal seed protocol system that obliges department to invest in. Further, there is no breeding section at any forest institute/ department to carry out production of improved plant species or multiplication of improved exotic species.

There are limited training opportunities for researchers involved in seed production practices to enhance their capacity in seed and seedling production. Similarly, very little research is conducted to understand the dynamics of seed bearing of forest trees such as identifying good sites and estimating when the next high seed production year is likely to occur, which is of utmost importance in seed collection. Even when budgets are made available, there is plenty of inflexibility in the mechanisms to utilise this budget by the research institutes, which makes the entire exercise tedious for all involved. An inventory of research and development outfits within the Forest departments in the provinces is provided in **Table 4**:

Table 4: Research and Development arms within provincial Forest departments

Province	Research and Development arms	Core functions
Khyber Pakhtunkhwa Forest, Environment and Wildlife department	Research and Development Directorate (R&DD)	• An overall service directorate in research and development activities for KP Forest department. • The mission of R&D Directorate is to facilitate the Khyber Pakhtunkhwa Forest Department in Conservation, Development and Sustainable Management of Forests and allied natural resources for the betterment of local, national, and international community.
Punjab Forest, Wildlife and Fisheries department	Punjab Forest Research Institute (PFRI	• Production & supply of quality seed • Conduct research on forestry & allied disciplines • Impart professional forestry education • Arrange training courses for foresters, farmers, NGO's etc.
AJK Forest, Wildlife and Fisheries department	AJK Seed Centre	• Identification of seed stands: The forestry seed centre 1st activity was to identify the seed stands of different species in different zones of AJK. Seed stands were identified • Identification of plus trees in each zone of different species of forest tress and marking it as a plus tree from which seed to be collected every year and will be provided to different forest divisions of AJK based on their demand.
GB Forest department	None	
Sindh Forest and Wildlife department	Planning, Research, Monitoring, Evaluation	This wing prepares and executes action plans for new research projects, coordinates research programmes, with other similar research organizations of the country; monitors and evaluates development projects of Sindh Forest Department; and runs a training school, where forest guards and game watchers undergo a six months' training course.

Based on this list, it seems that the direct mandate for systematic support in seed collection has been defined in case of PFRI and AJK Forest Seed Centre only. These set ups, however, have their own strengths and gaps yet a high potential exists for these to become centre of services for most of the country.

4.7 Summary of main issues and constraints in seed sub sector

1. Quality of forest seed is highly variable and inconsistent in the absence of uniform standards; prices do not vary as per quality of seed and thus little incentive for collecting high quality seed.
2. FSCRD provides quality control cover through registration of agriculture crops/ crop variety, crop inspection and seed testing. This system is being implemented at federal level under the Seed Act, 1976. For forest seed and seedling production, the same Act provides legal coverage, however, this is not the case in practice.
3. After 18th Constitutional Amendment, the role of PFI is limited to the province. However, PFI's role is almost negligible as a provincial institute. At country level, there is no comparable institute to play a role to provide technical support for quality seed production to the provinces.
4. The existing set up of the forest department in Pakistan including AJK & GB, do not prioritize support to production of quality certified seed technically and financially. The current capacity is very low.
5. The quality of documentation is poor for tracing seed sources and classification. All the work earlier performed is lost and thus requires a new effort.
6. Private nursery growers have no linkages with forest department for using and acquiring quality seeds or any other technical support. Therefore, the commercialization of forest nurseries is difficult besides question on quality of plants produced.

Chapter-5: Nurseries and propagules in public sector

In Pakistan, there are 1,115 nurseries[8] with a total area of 1,304 hectares maintained by the Forest departments at sub national level. These nurseries produce multiple species in a variety of ecological zone and fulfil 10-90 percent of the demand for planting stock in the provinces. The rest is procured from private nurseries. **Figures 5** and **6** summarize this data. The following sections provide situation in different provinces[9].

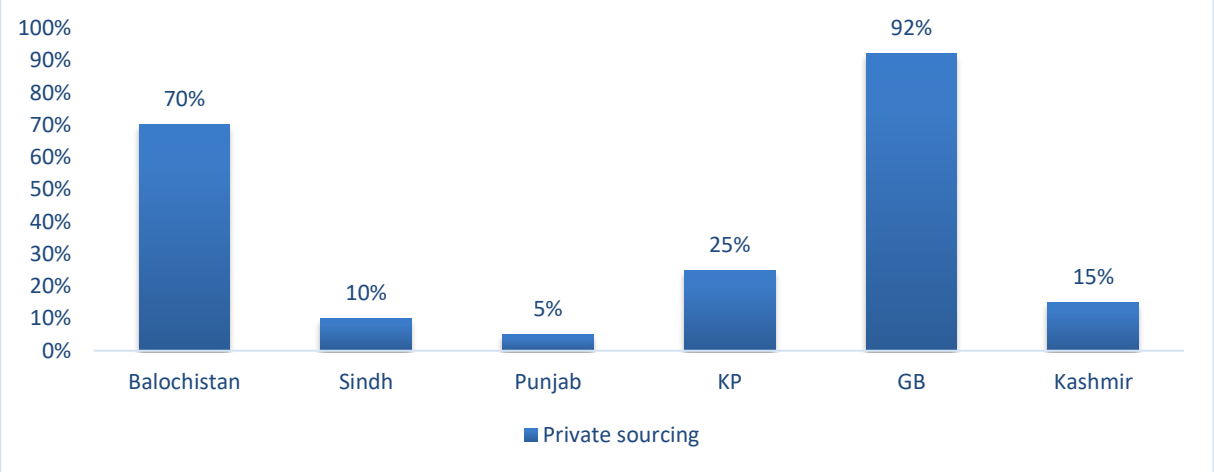

Figure 6: Private sourcing of plants by government

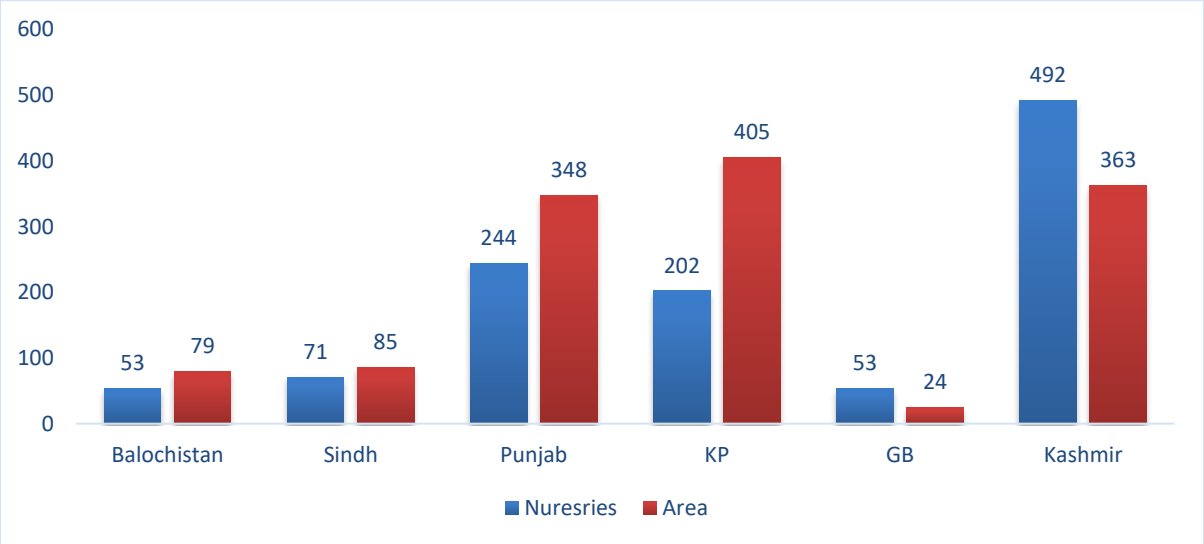

Figure 5: Overview of government owned nurseries (numbers and area in Hectares)

5.1 Punjab

Punjab has overall 244 nurseries including 174 hectares bed nursery and 251 million tube plants production capacity. Overall share of private nurseries in supplying forest planting material in the province is above 30%. The private nurseries mainly meet the demand of private sector in addition to supplying for to the government. The Forest department procures nearly 5-10% plants from private

[8] Number and size of nurseries may remain generally the same over longer periods. Production of plants in these nurseries however may change based on annual demand/targets of plantation set by the provincial governments. The targets keep changing based of priorities of the government
[9] It is important to note that the provinces maintain nursery data in different ways and details. It is therefore difficult to present data on a similar format and pattern.

nurseries. In the year 2020, however, the department did not purchase any plants from private nurseries because the department had enough production in forest nurseries. The department planted 147 million plants in 2020. In addition, 64.730 million plants were distributed to others, including communities, individuals, other government departments, private organizations, and NGOs **(Table 5)**.

Table 5: Number of plants produced in Punjab in public nurseries and distribution (2020)

Total production	Total production	Total distribution	Total distribution
Bare rooted nurseries (174 hectares)	Tube plants	Department's planting schemes	Non-departmental planting drives
17,400,000	251 million	147 million	64.730 million

5.2 Sindh

There are 71 government nurseries in Sindh with an overall area of 85 hectares. The nurseries produce planting material from different tree species and distribute to different planting schemes and projects (**Table 6**). The department receives about less than 5% of their seeds and seedlings from the private nurseries.

Table 6: Number of plants produced during the year 2020 in Sindh in public nurseries

Sr. No.	Name of Species	Plants Produced	Plants Distributed / planted
1	*Acacia nilotica* (Kikar)	1,356,000	1,064,500
2	*Azadirachta indica* (Neem)	2,465,700	1,573,080
3	*Delonix regia* (Gulmohar)	685,790	420,700
4	*Pongamia pinnata* (Sukh Chain)	1,165,780	987,400
5	*Albizia lebbeck* (Siris)	1,098,000	688,200
6	*Cassia fistula* (Amaltas)	209,870	155,000
7	*Moringa oleifera* (Moringa)	1,210,592	1,176,300
8	*Samanea saman* (Rain Tree)	56,890	56,890
9	*Ficus carica* (Fig tree)	46,235	25,400
10	*Bombax ceiba* (Simal)	440,650	355,250
11	*Eucalyptus camaldulensis* (Eucalyptus, Lachi)	600,000	350,000
12	*Conocarpus erectus* (Buttonwood)	645,850	600,000
13	Miscellaneous Fruit Plants	875,690	745,800
Total		**10,857,047**	**8,198,520**

5.3 Balochistan

Historically there were 20 government nurseries in Balochistan with an overall area of 20 hectares. The nurseries produce planting material to the tune of 1.5 to 2.0 million plants per year from different tree species and distribute to different planting schemes and projects. To fulfil the demand created by the Ten Billion Tree Tsunami Programme (TBTAP), more nurseries have been established. Currently there are 53 nurseries over 79 hectares (**Table 7)**. In addition, the department reportedly also purchased 250,000 plants from private nurseries.

Table 7: Plants produced by Balochistan Forest Department 2019-2020

Plants Raised Under TBTAP-Forestry 2019-20	
Potted	Bedded
3,906,687	1,668,128

The plant species produced in the nurseries are highly diverse due to requirements of ecologically diverse regions of the province - temperate in the north to coastal regions in the south. In total, 112 species were grown in the forest nurseries, which is by far the largest number of species raised by any province. The

procured plants include board-leaved species of public interest for distribution in public for planting under different schemes. During 2019-20, the 492,327 plants were distributed whereas in 2020-2021, 1,838,248 plants were distributed to public from the government nurseries.

5.4 Khyber Pakhtunkhwa

There are 202 government nurseries in Khyber Pakhtunkhwa with an overall area of 810.78 hectares of which spring nurseries are raised over an area of 402.94 hectares and monsoon nurseries cover and area of 407.84 hectares (average 405 hectares). The nurseries produce planting material from different tree species which are distributed to different planting schemes and projects (**Table 8**). The department purchases about 20-25% seeds and seedlings from private nurseries. This includes 2.8% of stock purchased from the established community nurseries supported by the department.

Table 8: Number of plants produced by Forest department KP for the last five years (in Millions)

Year	Monsoon	Spring	Total
2017	500.832	314.551	815.383
2018	133.627	88.941	222.568
2019	36.980	33.474	70..454
2020	122.929	123.855	246.784
2021	178.235	164.841	343.076

The department has distributed over 45 million plants to non-departmental planting schemes (13% of the total stock produced). The rest of the planting material produced is utilized in department's own planting schemes (**Table 9**).

Table 9: Plants distributed to others by Forest department in the year 2020 (in Millions)

Recipient Organisation	Spring	Monsoon	Total
VDCs	0.681	0.281	o.962
Defence office	3.322	1.278	4.6
Educational institutions	1.523	0.330	1.853
Farmers and other individuals	23.378	1.645	25.284
NGOs/others	11.378	1.302	12.68
Total	40.543	4.836	45.379

5.5 Azad Jammu and Kashmir

There are 492 government nurseries in AJK with an overall area of 363 hectares. Of these 11% area is allocated to production of tube plants, 38.5% for bare-rooted plants and rest of 50.5% produce both tube and bare rooted plants. Samplings of different tree species are produced in these nurseries and distributed to different planting schemes and projects. Plants produced are given in **Table 10**. The department buys about 12-15% of their seeds and seedlings requirements from the private nurseries. During the year 2020, the department purchased 3.671 million plants from private nurseries (**Table 11**).

Table 10: Number of Plants produced in AJK during the year 2020

A	Government/ FD Nurseries		
I	**Tube/ Containerized -** 12.499 million		
	1	*Cedrus deodara* (Deodar)	564,938
	2	*Pinus wallichiana* (Blue Pine)	726,593
	3	*Pinus roxburghii* (Chir Pine)	3,146,884
	4	*Abies pindrow* (Fir or Cedar tree)	2,554
	5	*Rubinia pseudoacacia* (Black locust)	694,325
	6	*Eucalyptus camaldulensis* (Eucalyptus)	2,515,628
	7	Others	4,847,679
	Total		12,498,601
II	**Bare roots -** 16.952 million		
	1	*Rubinia pseudoacacia* (Black locust)	8,939,766
	2	*Populus alba* (Poplar)	4,411,144
	3	*Salix babylonica* (Weeping Willow)	431,600
	4	*Ailanthus altissima* (Tree of heaven, Varnish tree)	378,944
	5	*Ulmus wallichiana* (the Himalayan elm)	484,809
	6	*Dalbergia sissoo* (Shisham)	928,234
	7	Others	1,377,155
		Total	16,951,652
III	**Containerized + Bare roots -** 9.900 (5-year average)		
	1	*Cedrus Deodara* (Deodar)	564,938
	2	*Pinus wallichiana* (Blue Pine)	726,593
	3	*Pinus roxburghii* (Chir Pine)	3,146,884
	4	*Abies pindrow* (Fir)	2,554
	5	*Rubinia pseudoacacia* (Black locust)	9,634,091
	6	Eucalyptus	2,515,628
	7	*Populus nigra* (Poplar)	4,411,144
	8	Salix Willow	431,600
	9	*Ailanthus altissima* (Tree of heaven)	378,944
	10	*Ulmus wallichiana* (the Himalayan elm)	484,809
	11	*Dalbergia sissoo* (Shisham)	928,234
	12	Others	6,224,834
	GRAND TOTAL		29,450,253

Table 11: Plants purchased by AJK Forest department from private nurseries (2020)

S#	Species	No. of Plants
1	*Pinus roxburghii* (Chir Pine)	797,466
2	*Rubinia pseudoacacia* (Black locust)	531,644
3	*Eucalyptus camaldulensis* (Eucalyptus)	265,822
4	*Populus ciliata* (Poplar)	398,733
5	*Salix babylonica* (Willow)	265,822
6	Iple Iple	318,986
7	*Ulmus wallichiana* (Kashmiri elm /Himalayan elm)	186,075
8	*Dalbergia sissoo* (Shisham)	348,227
9	Others	558,226
GRAND TOTAL		3,671,001

In 2020 the department planted and distributed around 33 million plants throughout AJK.

5.6 Gilgit Baltistan

Nursery raising is a difficult task in GB due to limited cultivable land, shallow and porous soils, and limited rainfall. As such, in the need for frequent irrigation channels constructed on mountain slopes require continuous maintenance and repair is a challenging task. Despite these challenges the Forest Department manages 53 nurseries in all over GB with an overall area of 24 hectares (**Table 12**).

Table 12: Number of Plants produced in GB during the year 2020

S.No.	Name of Species	No. of Plants Produced
1	Poplar Plants	198,200
2	Poplar long shoot cuttings	191,800
Total		390,000

However, the department mainly depended on private nurseries for procurement of plants. Demand for seed and seedling varies from year to year. Seeds are also mainly purchased from the private collectors. In 2020-21 nearly 1000 kg of mixed seeds (conifers and broadleaved) and,292,018 plants were purchased from private collectors and nurseries. Plants purchased from the private sector make 91.6% of the total demand for planting stock in GB (**Table 13**).

Table 13: Number of Plants purchased by GB Forest department during the year 2020

S. No	Name of Species Purchased	Number of plants Purchased
1	Poplar plants from GB Private Forest nurseries	94,500
2	Poplar shoots cuttings from GB farmers	2,460,973
3	Poplar plants purchased from down country	436,664
4	Rubinia purchased from down country	81,875
5	Ailanthus purchased from down country	27,291
6	Deodar plants from down country	175,590
7	Kail plants from down country	175,590
8	Ornamental plants (mix species) from down country	25,291
9	Fruit plants (mix species) from private nurseries	814,244
Total		4,292,018

In 2020, the department distributed a total of 4,682,018 plants to communities, individual tree growers, organizations, projects, and department's own planting schemes. Detail of type of plants distributed is given in **Table 14**.

Table 14: Name and number of species distributed by GB Forest department

Sr. No	Name of Species Distributed/planted	Number of plants Distributed/planted
1	*Populus nigra* (poplar tree)	292,700
2	*Populus nigra* (Poplar shoot cuttings)	2,652,773
3	*Populous deltoids* (Poplar tree)	436,664
4	*Rubinia pseudoacacia* (Black locust)	81,875
5	*Ailanthus altissima* (Tree of heaven)	27,291
6	*Cedrus deodara* (Deodar tree)	175,590
7	*Pinus wallichiana* (Kail or Pine tree)	175,590
8	Miscellaneous Ornamental trees (mix species)	25,291
9	Fruit trees (mix species)	814,244
Total		4,682,018

5.7 Plant production through tissue culture

Tissue culture is a technique through which an entire plant can be produced by growing the tissue or cells of a plant on an artificial growth medium necessary for growth of plant cell away from the parent plant. This method of growing plants is also known as micro propagation. For this purpose, suitable plant cells or tissue are cultured on a solid or semi-solid, or solid growth medium supplemented with suitable plant growth hormones. This technique involves following stages during production of a whole plant:

- Initially some tissue or cells of plant are removed from the parent plant and callus is produced on a petri plate containing growth medium
- The plant initiates from callus which is an undifferentiated mass of plant cells
- Shooting: for producing shoots a suitable hormone is added in the growth medium which supports cell differentiation into a shoot
- Rooting: addition of a rooting hormone imitates rooting producing a small plant
- Finally, the plant can be removed from the growth medium and inoculated on soil

Researcher state that in case of tree species, tissue culture is very difficult procedure, and the process takes longer than non woody species. Some commercially important species such as, Banana trees and date palm have been successfully grown through tissue culture. The per plant cost of these plants is much lower than growing in nurseries. Plant tissue culture is beneficial economically especially for plants which take longer to grow under normal environmental conditions. Tissue culture helps mass production and in reducing gestation period. Tissue culture is especially useful for tree species, which can produce only 2-3 baby plants in a year.

5.8 Tissue culture facilities in Pakistan

The following tissue culture facilities are available in Pakistan:

- ✓ International Centre for Chemical and Biological Sciences (ICCBS), Karachi University
- ✓ Department of Botany, University of Peshawar
- ✓ CCRI Multan
- ✓ Agriculture Research Centre: Tarnab, Peshawar (also work on woody plants)
- ✓ National Agriculture Research Centre (NARC), Islamabad
- ✓ Pakistan Council of Scientific Research (PCSIR)
- ✓ Private tissue culture labs
- ✓ University of Balochistan
- ✓ Faisalabad Agriculture University
- ✓ Agriculture Research Institute Rawalpindi

Unfortunately, none of these facilities works for propagation of forestry plants. These facilities are meant to support agriculture / horticulture. The research and funding for tissue culture on forest plants is not available.

Some laboratories such as Department of genetics Karachi University, Department of Botany at University of Peshawar, Central Cotton Research Institute (CCRI) Multan have started some experiments on tissue and organ culture. Tissue culture in coconut plant, *Commiphora wightii* (Guggal) and banana are proven success at **ICCBS** in Karachi.

The Tissue culture lab at the **Agriculture Research Institute Tarnab** in KP was established in the 90s under the supervision of Research wing of agriculture department. Research is conducted on potato, mushroom, **olive, and banana** supported by projects. Currently, the lab is financed under a project for newly merged districts and carrying research on potato.

The lab is producing potato plants for research purpose and not for commercial activities. The researchers claim that potato tissue can be produced commercially if resources are provided. They claimed that production protocols are prepared for potato but were not shared for this report.

The researchers at Tarnab lab stated that they can produce and multiply different woody plants through tissue culture. However, this needs facilities and financial resources which are not available. **Agriculture Research Institute Rawalpindi** has proven success on olive plants. All other tissue culture labs have a limited operation and are more engaged in horticultural and commercial plants.

In conclusion, currently no research on production of forest plants using tissue culture exist in Pakistan. Some of the existing labs can offer the service if funds and facilities are available.

5.9 Suggestions for forest departments and other stakeholders

For the Forest department and other stakeholders interested in propagating trees through tissue culture may utilize existing tissue culture facilities following the chronological steps given below.

- The stakeholders need to shortlist species of their priority and desired characters
- Collaborate with tissue culture research labs for conducting feasibility of these plants through tissue culture
- With the help of research labs develop protocol for the species propagation (duration, numbers, costs)
- Provide funding to the labs for research on tissue culture of sort listed species
- Provide funding for production on commercial scale

Chapter-6: Nurseries & propagules in private/community sector

There are estimated 13,474 private/ community nurseries in Pakistan (**Figure 7**). Most of these nurseries deal in horticultural plants for private and public sector users. Few nurseries allocate a small portion of the nursery for production of forest plants. It is because demand for forest plants is low and unpredictable. Also, there is a stark difference among nurseries in size and number of plants they produce.

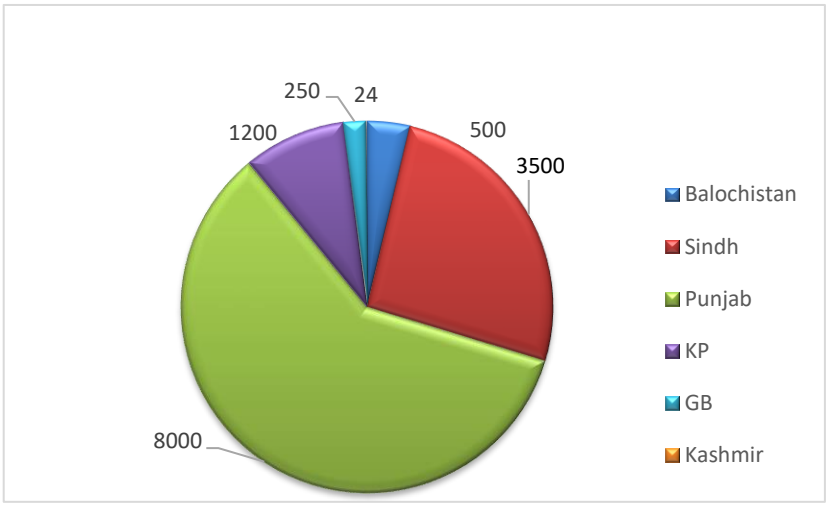

Figure 7: Private nurseries in Pakistan

Nurseries in Punjab and Sindh are smaller in size and scattered whereas in GB and Balochistan larger size centralized nurseries are more common. Cost of land could be a factor because cost of land in Punjab is quite high, and it is expensive to rent spaces for nurseries. Nursery growers, therefore, look for smaller pieces of land which are not suitable for other uses and are available at a low cost, for example, nurseries raised by roadsides along the bridges. Also, private buyers in Punjab and Sindh are many and mostly scattered in urban areas in the cities where costs are high for being located closer to the buyers. Therefore, nurseries are smaller in size.

The Forest department of KP and GB support community-based nurseries with buy back agreements of certain number of plants (e.g., maximum 25,000 plants per nursery in case of KP). With two consecutive large scale afforestation projects (BTAP and TBTAP), this trend has gained momentum (especially in case of women nursery farmers). It is not certain if the nursery farmers will continue this activity as a micro-business if the government stops buying from these nurseries.

Province wise assessment of private/community nurseries is given in the following sections.

6.1 Punjab

The total estimated number of private nurseries in Punjab is 8,000 to 10,000. There is a large difference in size of these nurseries ranging between 0.5 Acres to 50 Acres in different areas of the province. Most of these nurseries deal in horticultural and landscape plants / trees. Most of the plants are sold to individual buyers, housing schemes / private organizations, and to the provinces of Balochistan, Sindh and to some extent KP. Very little number is purchased by Forest department in Punjab.

The nurseries in Punjab have sufficient access to seeds for raising nurseries. The seeds are either bought from the authorized seed sellers or collected by the nursery owners themselves Mostly, the seeds used for nurseries are of high quality. A few nursery owners were, however, not sure about the quality of seeds.

Half of the nursery owners reported facing challenges accessing appropriate equipment and tools for nursery established. They believe that availability of latest machinery and equipment will help growing produce larger number of seedlings. In addition, around 76% of the nursery owners reported easy availability of skilled labour that can work effectively whereas 24% find their availability a problem. However, all of them reported that their human resources needed proper training and equipment to produce quality of seeds and propagules.

Demand for propagules keeps fluctuating. 47% nursery owners said that demand for nursery plants is low whereas 42% reported high demand. The remaining 11% considered it as per their expectation. 62% nurseries sell large proportion of plants to the consumers directly. 38% nurseries sell their seeds and seedlings to the whole sellers. There was a high demand for tree seedlings housing schemes under construction. Most of the nurseries collaborate with each other for production and sale of nursery plants. Availability of funds appears as the biggest and most common problem faced by nursery owners in Punjab. Other problems include scarcity of water, lack of and expensive machinery (tiller machine, sprayers).

6.2 Sindh

Large numbers of private nurseries are operational in different areas of Sindh. A crude estimate is 3500 nurseries of which 1000 nurseries are in Karachi. These nurseries sell both horticultural and forest plants. Horticultural plants usually make a larger segment of the nursery planting stock. The buyers include Forest department, private buyers (individual and organizations) as well buyers from province of Balochistan (public and private) in the form of feeder or distributor nurseries.

These nurseries mostly rely on the seeds collected by themselves within neighbourhood of nurseries. Nearly 73% nursery owners collected seeds from plus trees whereas 50% nurseries buy the seeds from random seed stores (including 27% who exclusively rely on bought seeds). The quality of seeds is reported as superior by 50% of the nurseries whereas 25% nurseries have no knowledge about the quality of seeds they utilize.

Nearly half of the nursery farmers considered lack of equipment and machinery as a hurdle for efficient production of seeds and seedlings. Around 75% of the nursery farmers reported easy availability of skilled workers and that their workers did not require any training whilst 23% reported facing difficulty in finding skilled labour and felt that their workers needed training in nursery techniques.

In terms of demand, 50% of private nursery farmers reported high demand, 32% reported low and 9% nurseries reported a medium demand for their seeds and plantlets.

Around 70% of the nurseries reported meeting demands of consumers whilst others could not meet consumer demand. Lack of funds, water scarcity, lack of skilled workers, machinery, and availability of space were viewed as major problems in establishment of nurseries. There were no seed orchards in the province to cater to the needs of the private nurseries. The nurseries collaborate with each other in production and marketing.

6.3 Balochistan

According to a rough estimate, there are 500 private nurseries in Balochistan. These nurseries have little or inconsistent tradition of producing forest plants. Most of the nurseries produce fruit plants or horticultural plants which are high in demand for home gardens or urban plantations for beautification. Private nurseries of Sindh and Punjab cater to the needs of Balochistan. According to Balochistan Forest Department, there were around nine private nurseries which served as distributors of plants procured from Pattoki (Punjab) and Hyderabad (Sindh):

- Sibi: 1 nursery (seasonal)
- Dera Murad Jamali: 3 nurseries (all year round)
- Dera Allah Yar: 3 nurseries (all year round)
- Usta Muhammad: 1 nursery (all year around)
- Sohbatpur: 1 nursery (all year round)

The private nurseries in the province dealing with ornamental and other plants buy seeds from different authorized seed stores. The quality of seeds is thus mostly superior. Low-quality seeds are also used.

The nursery owners also collect seeds for their requirements from random trees without any plus tree selection. There is no seed orchard managed by Forest department Balochistan.

Plants are sold mostly to the private buyers (individuals, whole-sellers, and other enterprises) and to a limited extent to the Forest department. Only 250,000 plants were purchased in 2019-2020. Around half of the nursery farmers reported lack of availability of equipment and skilled labour and need for training. The demand of plants produced in the nurseries was reported to be high with only 23% of nursery farmers reporting difficulties in selling plants. The nurseries collaborate with each other and are interdependent for marketing.

6.4 Khyber Pakhtunkhwa

KP has a long and well-established tradition of nursery establishment for production of fruits and forest plants. An estimated number of private nurseries in the province is 1200 of which majority are located in Peshawar and central KP regions. These nurseries produce a limited number of forest plants and other plants used in avenue or landscape planting in urban areas. A unique feature of KP is the establishment of community-based nurseries supported by the Forest department on a buy back guarantee. This tradition started with the Dutch funded Social Forestry project (1989-1999) and WFP's Environment Rehabilitation Project (1992-1998) later upheld by Forestry Sector Project of the ADB. This experience was replicated by BTAP (2014 onwards) and is currently supported by TBTTP. Currently, a total of 74 community nurseries are raised during spring season and 199 nurseries during the monsoon (2021). Many of these nurseries are tended by women. Each nursery is expected to produce around 25,000 plants **(Table 15)**.

Table 15: Number of plants produced in KP by communities during the last five years (in Millions)

Year	Monsoon	Spring	Total
2017	185	240.3	665
2018	63.275	23.05	86.325
2019	3.075	0.125	3.2
2020	0	1.850	1.850
2021	4.975	4.5	9.475

The main species produced in the private nurseries include *Cedrus deodara* (Deodar), *Pinus wallichiana* (Kail), *Pinus roxburghii* (Chir), *Rubinia pseudoacacia* (Rubinia), *Acacia modesta* (Phulai), *Dalbergia sissoo* (Shisham), *Eucalyptus camaldulensis* (Eucalyptus), *Populus* spp., *Juglans regia* (walnut), *Ailanthus altissima* (Ailanthus), *Albizzia lebbek* (Sirin).

78% of the nursery farmers buy seeds and propagules form the market. They also self-collect seeds and propagules for their own requirements and for sale. Seed are purchased both from authorized sellers as well as from unauthorized seed stores. Only one nursery reported that they buy seeds from seed research centre. All the nurseries, however, claimed that they use quality seeds. Half of the nursery owners believe that they have sufficient machineries and equipment required for their nurseries whereas, the rest complained shortage of equipment. Skilled nursery labour is available depending on the season. There is a competition for labour during early monsoon for demand in rice transplanting fields in southern KP and central Punjab. Monsoon is also an engaging period for other agricultural operations in central KP including tobacco curing.

Most of the nurseries stated that the demand for plants was good but, in some years sudden fluctuation in demand was noticed resulting in financial losses to the owners. The buyers included whole sellers, Forest department, retailers, and individuals. The nurseries cooperate with each other for procurement of material and sale of plants. It is important to note that most plant stocks were procured from Punjab, though there existed scope for establishment of nurseries by the private sector in diverse climatic regions.

6.5 Azad Jammu and Kashmir

There are 24 private nurseries in AJK over an area of 103 hectares. On average, these nurseries produced 4 million plants. Out of these, nearly 81% plants were purchased by the Forest department (over 3.3 million) during the last five years. Except for *Pinus roxburghii*, all the species raised by private nurseries were broad-leaved.

Seeds are purchased from authorized dealers and are reported to be of superior quality. The lack of equipment was an impediment for efficient plant production. Skilled labours were reported easily available. High demand for nursery plants and a good collaboration among nursery farmers existed for marketing of planting stocks.

6.6 Gilgit Baltistan

GB's private nurseries seem to share the largest proportion of seedlings to the public and private sector. A private nursery at GB has 5-10 kanal area on average and it supplies 18,000 plants. There are roughly around 250 private nurseries in GB. Recently, GB has started to produce plants on buy back agreements with nursery entrepreneurs. Poplar is the main tree species, which is multiplicated through cuttings.

Nursery owners buy their seeds from Swat and from their neighbours. Skilled labour is generally not available except in the Forest department managed nurseries. This is due to the fact that, nursery-raising coincides with the agriculture cropping season (ploughing, sowing, weeding of maize wheat, potato etc.), therefore, shortage of labour is faced. Lack of skilled manpower to manage nurseries remains a problem. Most of nursery farmers sell plants to private buyers except the nurseries contracted by the Forest department which sell plants to the department. The demand for nursery stocks fluctuates, with commencing and ending government afforestation projects. Plants are also procured from Swat and Haripur as local nurseries fail to fulfil high demands created by newly initiated projects. Shortage of inputs (e.g., fertilizers), and irrigation water are the main problem faced by the private nursery entrepreneurs. Free grazing is also a challenge due to which fencing becomes necessary, which adds another cost in production.

6.7 Issues/Challenges faced by private nursery farmers

6.7.1 Machinery/equipment impediment

There is a significant impediment regarding access to machinery and relevant equipment for nursery raising, management, and seed collection. 49% respondents in KP and 14% in Sindh reported that they were fully equipped with relevant means and could access required machinery and equipment. In other provinces, lack of machinery/equipment was reportedly a key impediment (**Figure 8**).

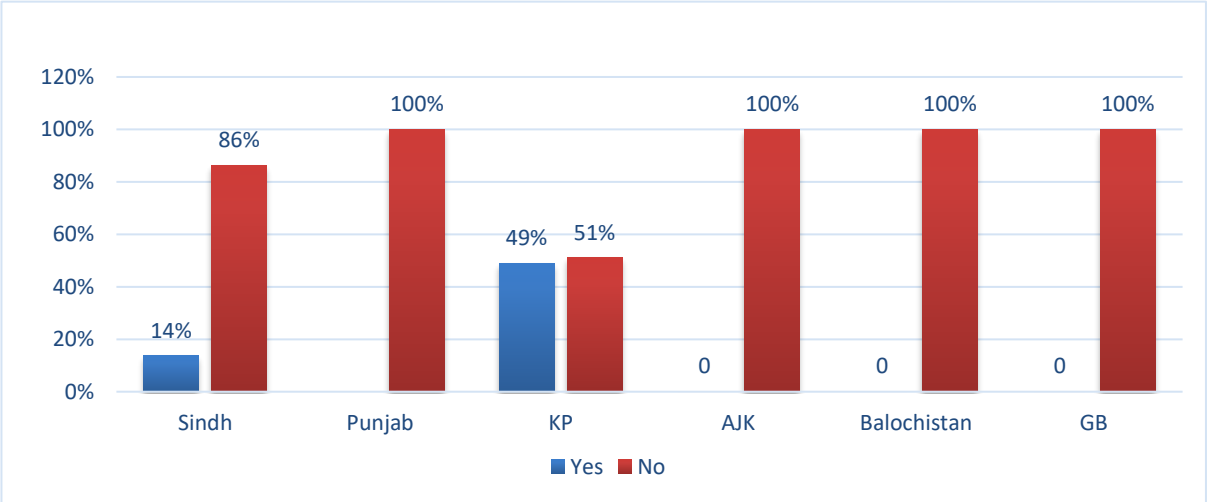

Figure 8: Machinery / Equipment Impediment

6.7.2 Availability of skilled labour

Overall, skilled human resource in Sindh, Punjab, KP and AJK is relatively easily available. Shortage of skilled human resource was reported by 50% of the respondents in GB and Balochistan (**Figure 9**).

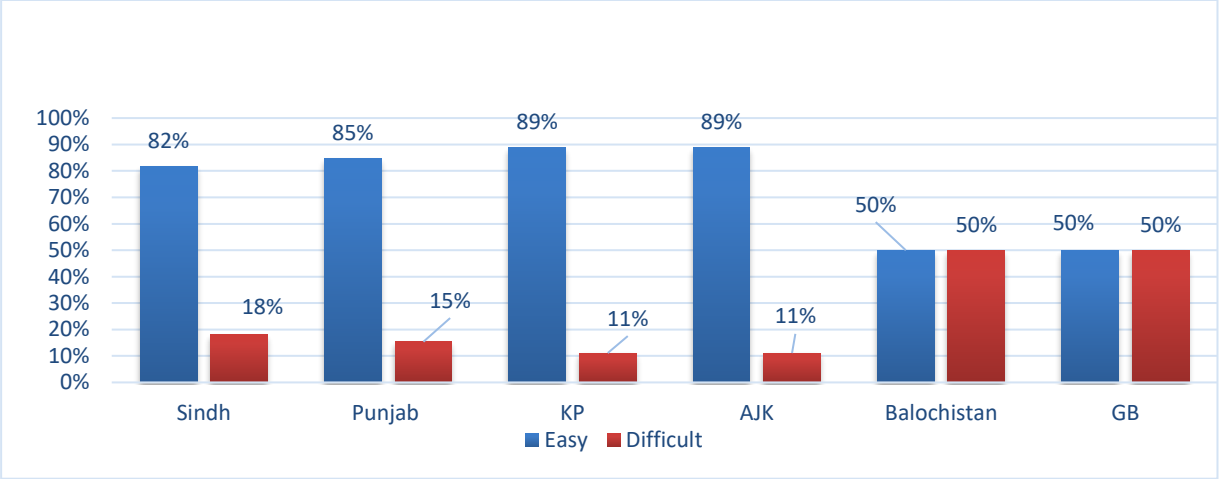

Figure 9: Availability of skilled labour

6.7.3 Other issues

Nursery owners face water scarcity (especially in Sindh, KP, Balochistan and GB) and shortage of fund (especially in Punjab, KP and AJK) (**Figure 10**). Other concerns included lack of market information on demand, unpredictable demand from the market and risk prone land tenure especially in case of small nurseries which are located on marginal lands with insecure or informal lease agreements.

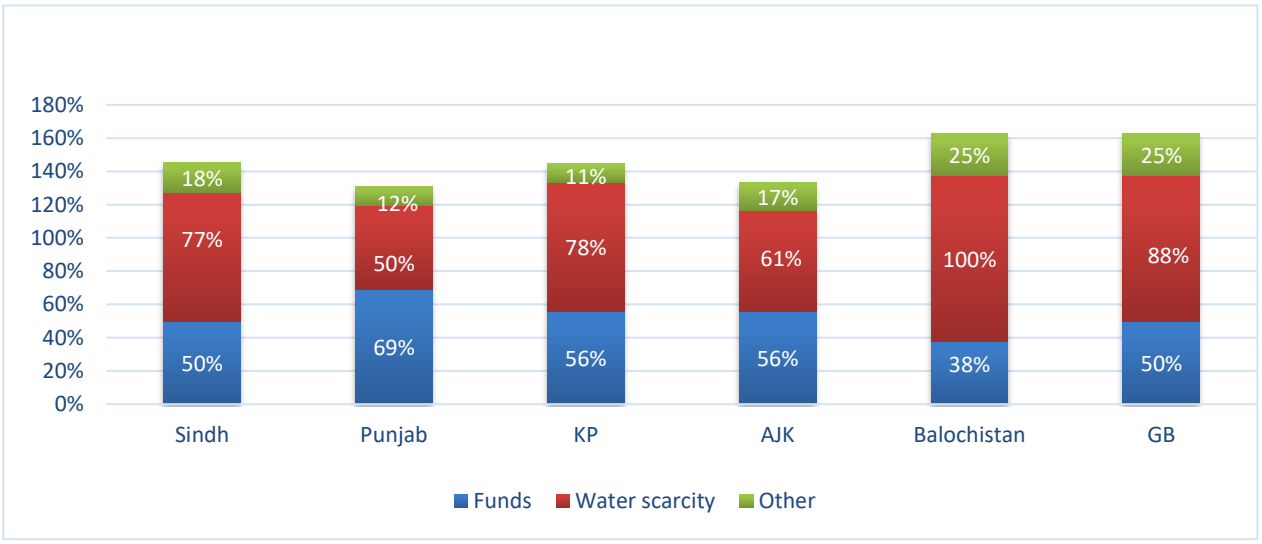

Figure 10: Difficulties faced by the Nurseries

Chapter-7: Economic overview of seed and seedling sub sector

7.1 Demand and supply

7.1.1 Public sector

Overall, demand of plants in recent years has increased due to major afforestation programmes in the country and increased awareness among masses. The demand is normally met from public nurseries; however, there is also specific demand for certain species such as fruit plants, shade plants, trees with aesthetic and ornamental value and without thorns. These plants fetch high prices in the market and are often available from private nurseries. A general overview of supply and demand in public sector for seedings in 2020 is given below:

- In **Sindh**, apart from plants raised from seeds and cuttings in forest nurseries, sometimes Kikar seed are also available for interested growers, government organizations, and NGOs on subsidized rates as notified by government from time to time. Sindh required 8,198,520 plants out of which very little proportion of 409,000 plants was purchased. The department was generally self-sufficient in planting / seed stock.
- **Balochistan** stated that historically the annual demand and supply of forest plants in Balochistan used to range between 1.5 to 2.0 million plants and were raised in Forest Department Nurseries. However, the situation changed after launch of TBTTP with a total target of 100 million plants by 30 June 2023. In FY Year 2019-20, seed utilized for raising of some 13 million plants across Balochistan in TBTTP nurseries.
- In case of **Punjab**, the department planted 147 million plants in 2020. In addition, 64.730 million plants were distributed to others (including communities, individuals, other government departments, private organizations, and NGOs) out of total stock of 252 million plants produced by the department. No plants were purchased from private nurseries in 2020.
- **KP** produced 343 million plants and purchased 68.615 million and the entire planting stock was used in various schemes in 2020 including private distribution.
- **AJK** planted 33 million plants in 2020. For this, 29.45 million plants were produced by the department and 3.671 million were purchased.
- **GB** required 4,682,018 plants in 2020 and purchased most of these plants. The department produced 390,000 plants and purchased 4.292 million.

7.1.2 Private sector

The target markets for fruit and forest plant nursery businesses include Orchard / woodlot growers, small, medium, and large scale residential or national highways along with huge local markets in Karachi, Lahore, and Islamabad. There is a high demand for plants in Balochistan and GB whereas in Sindh, Punjab, KP and AJK, a trend of low demand for forest plants is prevailing in private nurseries. The situation is mostly because of more inclination towards horticultural plants for gardens and landscape management (**Figure 11)**.

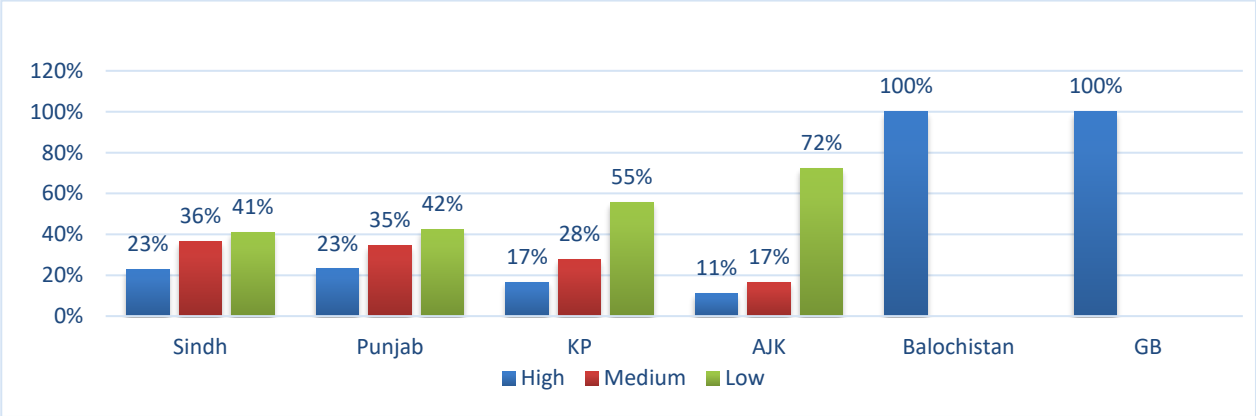

Figure 11: Respondents' (%) assessment of demand for forest plants by sub national units

In Balochistan and GB, plants are mostly sold to the respective Forest departments. A considerable portion i.e., 14% in Sindh, 33% each in KP and AJK is also sold to the Forest departments. In other cases, a large portion of the nursery produce is sold directly to consumers including private organizations (**Figure 12**).

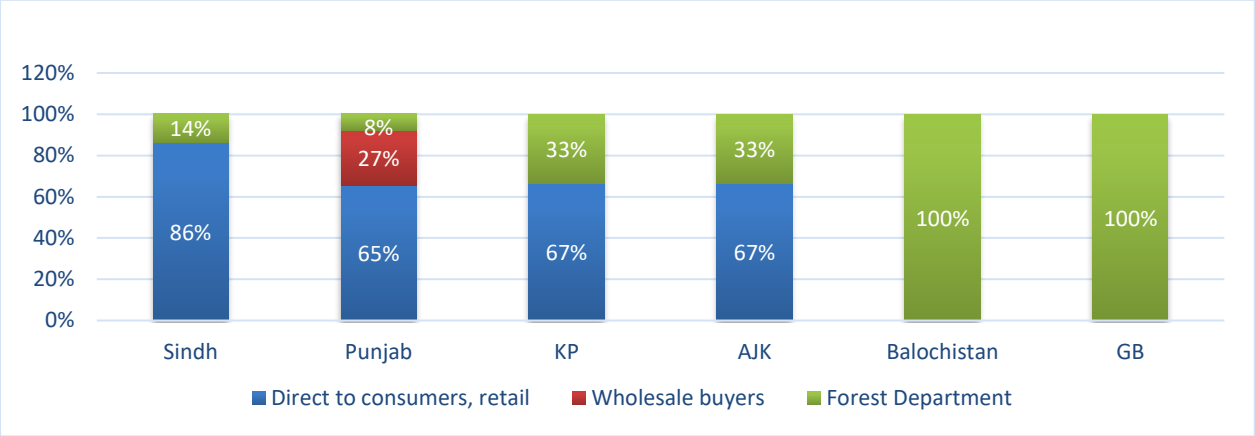

Figure 12: Who are the potential buyers

7.2 Income and employment

7.2.1 Public sector

A precise number of human resources engaged in public sector for managing nurseries is not known. Regular staff of government are either fully or partially assigned to manage nurseries. In addition, government also relies on temporary labour for seasonal tasks and pays them through muster rolls. An approximate number of human resources for seed / nursery management in the provinces in provided in **Table 16.**

Table 16: Human resource engaged in public sector

Province	Regular staff	Temporary staff	Total
Punjab	264	3000	3,264
KP	120	3600	3,720
Sindh	350	284	634
Balochistan	40	320	360
GB	40	1,000	1,040
AJK	84	4,000	4,084
Total	**898**	**12,204**	**13,102**

7.2.2 Private sector

Nursery raising is a growing enterprise in Pakistan in the private sector. Communities engaged in seed collection, identification and protection of stand and their protection can earn extra income. There is also a high potential for their systematic engagement in nursery management enterprise.

Data on employment generation in nursery/seed sector is not available as such data is not collected and maintained by any institutions in the country. However, analysing data from 100 private nurseries in this study indicates that nurseries and seed business employ a reasonably modest segment of population, especially youth and landless. The estimated projection from this study suggests 125,031 individuals employed by private nurseries on full time basis. The details are as follows (**Table 17**):

Table 17: Number of nurseries and workforce engagement in private nurseries by provinces

	Sindh	Punjab	KP	Balochistan	AJK	GB	Total	Estimated labour engaged in nursery sector*	Labour specifically for forest plants**	Seed ***
Total nurseries	3,500	8,000	2,790	500	24	250	15,064	125,031	53,384	5,170
Pure forest plants	350	800	279	50	2	25	1,506	7,532	7,532	1,039
Forest and fruit plants	1,225	2,800	977	175	8	88	5,273	52,724	26,362	1,819
Forest, fruit, floral plants	1,400	3,200	1,116	200	10	100	6,026	60,256	20,085	1,247
Short duration contracts	525	1,200	419	75	4	38	2,261	4,519	4,519	1,559

* Approximate calculated on the basis or surveyed sample: (i) 5 labour per nursery in pure forest nursery (ii) 10 labour per nursery in case of mixed nursery (iii) 2 labour per nursery in case of short duration contract nurseries
** labour specific to forests in case of mixed fruit/forest nurseries calculated @50% whereas in case of fruit, forest, and floriculture @30%
*** Assuming 23% nurseries purchase seed from seed collectors (as per data in this study)

As per the above analysis, an approximate labour employment in seedling production of forest plants is around 53,384 individuals from private-community owned nurseries whereas in addition, seed selling generates income for some 5,170 individuals. This, and the level of income earned by the enterprises, may further improve by introducing systemic improvement in the sector.

7.3 Economics of public and private nurseries

Table 18 describes per unit cost of different species grown in different geographical locations of Pakistan. This also presents comparative economics of the given species grown in private and public sector nurseries. Private nurseries in Sindh produces Kikar and Neem plants @Rs.8.80 and 8.97 per plant as compared to Rs.17.58 and Rs. 17.65 by government department. In Punjab, per unit Shisham plant in the government nurseries is produced @ Rs.8.28 as compared to Rs.7.08 in the private sector. Similarly, the cost differential in Balochistan between public and private sector nurseries is high for producing Kikar plant. Private nurseries are more efficient (Rs.7.46 per plant) when compared to the government nurseries (Rs.9.08 per plant). It shows that the cost incurred per seedling in Islamabad is Rs.11.86 in private nursery when compared to Rs.18.94 in government nursery, which shows that private nursery is more economical.

Table 18: Summary of per unit cost of plants (PKR) – private vs government nurseries

Province	Species	Private Nursery	Govt. Nursery	Difference	Method
Islamabad	Kachnar	11.86	18.94	-7.08	Bare Rooted
	Amaltas	11.86	18.94	-7.08	Bare Rooted
	Willow	11.86	18.94	-7.08	Bare Rooted
Punjab	Shisham	10.24	18.88	-8.64	Bare Rooted
	Arjun	11.72	19.26	-7.54	Bare Rooted
	Bakain	11.72	19.26	-7.54	Bare Rooted
Sindh	Kikar	8.8	17.58	-8.78	Bare Rooted
	Neem	8.97	17.65	-8.68	Bare Rooted
Gilgit Baltistan	Poplar spp	9.3	20	-10.7	Bare Rooted
Azad Jammu Kashmir	Ailanthus	5.94	10.92	-4.98	Bare Rooted
	Kail	8.64	12.44	-3.8	Tube
Khyber-Pakhtunkhwa	Chir	7.44	8.5	-01.06	Tube
	Poplar spp	6.68	9.26	-2.58	Bare Rooted
Balochistan	Kikar	9.09	11.58	-2.49	Tube

Similarly, in GB the total cost of poplar is Rs.9.3 in private nursery when compared to government Rs.20 whereas sale Rs.25-30 for 8ft height and 1 inch diameter, showing the private nursery is much economical than the government nurseries. Whereas in KP the per plant cost in private nurseries is Rs.7.44 for tube whereas Rs.6.68 for bare rooted plants as compared to Rs.8.5 for tube plants and Rs.9.26 for bare rooted plants. In AJK the tube plants in private nursery costs Rs.8.64 when compared to government Rs.12.44, and bare-rooted Rs.5.94 in private against Rs.10.92 in government nursery.

Cost benefit ratio

Cost benefit ratio (CBR) has been calculated at market price of the plants sold from the private nurseries (**Table 19**). The CBR for government nurseries has not been calculated since mostly the plants are distributed for free or on a highly subsidised rates with an intention to promote afforestation and not for profit generation.

Table 19: Benefit cost ratio of selected plants in private nurseries

Province	Species	Private Nursery – cost of production (PKR)	Ave. sale rate (PKR)	Cost Benefit Ratio
Islamabad	Kachnar	11.86	100	1:8
	Amaltas	11.86	500	1:42
	Willow	11.86	100	1:8
Punjab	Shisham	10.24	35	1:3
	Arjun	11.72	35	1:3
	Bakain	11.72	50	1:4
Sindh	Kikar	8.8	50	1:6
	Neem	8.97	50	1:6
Gilgit Baltistan	Poplar spp.	9.3	28	1:3
Azad Jammu Kashmir	Ailanthus	5.94	50	1:8
	Kail	8.64	60	1:7
Khyber Pakhtunkhwa	Chir	7.44	25	1:3
	Poplar spp.	6.68	28	1:4
Balochistan	Kikar	9.09	50	1:5

This comparison shows the potential of private nurseries all over Pakistan. In general, the private nurseries are comparatively more competitive in terms of price, as in the case of government nurseries. If promoted as a productive sector, the private nursery sector can create significant income for owners and associated labour force.

Chapter-8: Conclusions and Recommendations

8.1 Key conclusions

1. All over the country there are a total of 1,115 nurseries in public sector with a total area of 1,304 hectares. These nurseries support multiple species in a variety of ecological zone. These nurseries fulfil 75% planned planting target of the forest departments. The rest is covered by procurement from private nurseries.
2. Plant produced in public sector greatly fluctuates due to initiation and completion of time bound development projects.
3. There are 13,474 private nurseries in Pakistan. Most of these nurseries deal in horticultural plants mainly sold to private users and landscape planners. These nurseries also grow forest plants in limited quantities.
4. Cost-benefit comparison of selective species shows that private nurseries are financially more competitive than public sector nurseries.
5. Distribution of forest plants for free and on subsidized rates distort market and discourage production of forest plants in private nurseries.
6. Private nurseries generate employment for 53,384 individuals specifically engaged in raising seedlings of forest plants (this is 50% of the total labour force engaged in private nurseries in Pakistan). In addition, 5,170 individuals acquire temporary jobs in seed collection sector. The public sector nurseries employ 13,102 individuals, 898 permanent employees for looking after nurseries and 12,204 temporary labour per year.
7. There is currently no quality control and set principles for nursery growers to produce healthy and diseased free saplings.
8. Seeds of important species are purchased large quantities through tenders whereas seeds for other species are managed through labour engaged on muster rolls. For the latter category, price mechanism is not an incentive for collecting better quality. This discourages seed collectors in assuring quality of seed collected.
9. The seed collection practices are mostly primitive and there is no system to check quality of seed. Quality of seed is manually checked by experienced staff at the time of purchase.
10. Skills in nursery raising in the private sector is mainly acquired through practice. There are no training facilities for the private sector on producing quality germ plasm (seed collection, production, processing, and seedling production/nursery techniques).
11. There is no formal forest trees seed business. People living around forest or having contact with forest departments collect seed and sell to the forest departments.
12. The system of seed collection is not institutionalized nor is protected by any quality protocols.
13. Profitability of seed production and payment of premium by quality compliance for the private seed collectors is essential to induce incentive and quality in the seed supply system. A healthy competition for good quality seed among collectors may be useful so that quality of seeds and seedlings is not compromised.
14. Overall demand for nursery propagules is increasing due to large scale afforestation programmes and public awareness.
15. There is no facility for tissue culture for forest plants. Available facilities belong to the agriculture sector which conduct research on non woody plants.
16. Systematic data on number of nurseries, nursery wise area, nursery wise species and species wise annul production in public nurseries is generally not maintained.

8.2 Key recommendations

Seed sub sector:

1. The public sector universities have large land endowments, which may be utilized for seed research and certified production. This will require a small area with high return.
2. Seed Act 1976 governs the seed supply system in Pakistan. Amendments to this Act was adapted in 2015 "Seed amendment Act" to grant permission to the private sector to produce basic seed, if authorized by the provincial governments which gives legal coverage to certified seed production of plants including forest trees. Therefore, it is legal to initiate the certified seed production of forest tree in coordination with FSCRD.
3. There is a need to identify new seed stands and mark plus trees in different ecological zones in Pakistan through a truth and labelling methodology by the Forest departments in consultation with FSCRD. These resources may be properly marked by a team of experts comprising experts from Forest departments, FSCRD and documented for best morphological and genetic characteristics. These trees must be tended and maintained under the guidance of the FSCRD[10].
4. A permanent and stable seed delivery system in forestry sector, accompanied by high genetic technology, is a necessity in the country.
5. Already involved private seed collectors should be linked with seed orchards / plus tree sites for collection of quality seed from the marked plus trees only.
6. Seed collected needs to go through testing at designated institutes for quality control before provision to the Forest department or private sector for nursery raising.
7. Regarding certification, FSCRD is main legal institution most adequately and systematically designed for conducting seed certification activities, also for forest species. However, FSCRD may confront issues with expertise in forestry sector. Therefore, the role of PFRI and PFI may be raised to certification agencies under the legal cover and technical auspices of FSCRD.

Capacity building

8. Skill training programmes are necessary for nursery owners, especially small nurseries and women owned nurseries.
9. It is necessary to remove major and obvious bottleneck faced by the nurseries (lack of reliable water source, equipment, seed).
10. A formal system for record keeping and literature on the forest trees and vegetation needs to be generated and maintained in research institutions, and that could be accessed by the researchers and communities.
11. Proper training for private or public sector nurseries may be helpful for reintroducing the idea of seed orchards. Thorough knowledge and history of aborigine's plants and tree species would be required for such activities.

Nurseries establishment, nursery economics and record keeping

12. The Forest departments across country need to take a decision on opting either production or regulatory role. Currently, the department is a producer and in direct competition with private nurseries, thus not encouraging private sector to enlarge seed and seedling business and invest in quality. It is recommended that the departments establish quality assurance standards and leave the production to the private sector. Only highly specialised and selected species may be produced in government nurseries.
13. Private seed and seedling producers may be encouraged through different incentives by the department for producing good quality material. This will help promoting high quality germ plasm production in forestry sector.
14. It is important to take incremental measures to shift nursery production from public to private sector due to better profitability and to generate sustainable business, employment, and healthy competition in the sector.

[10] Seed amendment act 2015 defines truth and labelling as *"truthfully labelled seed"* means seed of a registered variety or hybrid produced locally or imported and which conforms to standards as prescribed under the rules.

15. To encourage private sector, relatively medium or long-term contracts to the nurseries for forest plants production may increase security in planting stock supply system, increase sustainability of private nurseries, and rationalize costs.
16. Establishment and operational sustainability of forest plants tissue culture labs and seed banks at provincial level would be instrumental for enhancing availability of planting material. This will require funding and infrastructure. These resources may be made sustainable if they prove cost effective and profitable already existing resources and institutions may be utilized for this purpose to further strengthen this arrangement.
17. Planting material needs to be more accessible within major regions for supporting planting activities.
18. It is important to introduce registration / documentation of nurseries within the provinces and acquire a careful estimate of types of plants produced for better planning of public afforestation schemes and to extend support for quality assurance of the plants.
19. For a better planning it is important to develop data base to maintain data on annual demand and production – number of nurseries and area, species produced, species wise annual, nursery wise production, plants purchased from private nurseries and plants distributed to others outside the forest departments.

REFERENCES

1. Aalbæk, A. (1997). Demand and supply patterns for tree germplasm among farmers in the northeastern highlands of Tanzania. Paper prepared for workshop at ICRAF, 6–8 Oct 1997
2. Babalola, F.D. (2008). Assessment of small-scale private nursery enterprises in Ibadan, Oyo State, Nigeria. Small scale for 7(3/4):263–273
3. Background study paper no. 44. 9th meeting of the Working Group on Access and Benefit-sharing held in Cali, Colombia, 22–28 March 2010
4. Böhringer, A., Ayuk, E.T. (2003). Farmer nurseries as a catalyst for developing sustainable land use systems in southern Africa. Part B: support systems, early impact, and policy issues. Agric Syst 77(3):203–217
5. Cacanindin, D.C. (2010). Pilot testing of the forest nursery accreditation system in the Philippines DENR region 10. In: Harrison SR, Bosch A, Gregorio NO and Herbohn JL (eds) Improving the Effectiveness and Efficiency of the Philippines Tree Nursery Sector. Proceedings from the Mid-term Workshop held in Baybay, Leyte, the Philippines. 13 Feb 2009. pp 67–72
6. CTSP. (2003). Tree seed supply and distribution. Cambodia Tree Seed Project, Phnom Penh
7. CTSP. (2004). Costs, benefits, and enabling conditions related to village seed supply systems. Cambodia Tree Seed Project/Forestry Administration/Danida, Phnom Penh
8. Dawson, I., Were, J. (1997). Collecting germplasm for trees: some guidelines. Agrofor Today 9(2):6–9
9. Denning, G.L. (2001). Realizing the potential of agroforestry: integrating research and development to achieve greater impact. Dev Practice 11(4):407–416
10. Garcia, M.B. (2002). Growing agroforestry trees: farmers' experiences with individual and group nurseries in Claveria, Philippines. Unpublished paper. ICRAF, Claveria, Misamis Oriental, Philippines
11. Graudal. L., Lillesø J-PB. (2007). Experiences and future prospects for tree seed supply in agricultural development support. DANIDA Working Paper. Copenhagen, Denmark, p 35
12. Harrison, S., Gregorio, N., Herbohnt, J. (2008a). A critical overview of forestry seedling production policies and practices in relation to smallholder forestry in developing countries. Small Scale For 7(3/4):207–223
13. He, J., Yang, H., Jamnadass, R,, Xu, J., and Yang, Y. (2012). Decentralization of tree seedling supply systems for afforestation in the West of Yunnan Province, China. Small scale for 11:147–166
14. Herbohn, J., Gregorio, N., Harrison, S., Vanclay, J., Bosch, A. (2011). Enhancing tree seedling supply via economic policy changes in the Philippines nursery sector. ACIAR Final Report no. FR2011-08. Canberra. p 89
15. Koffa, S.N., Roshetko, J.M. (1999). Farmer-managed germplasm production-diffusion pathways in Lantapan, Philippines. In: JM Roshetko, DO Evans (eds) Domestication of agroforestry trees in Southeast Asia. Forest, Farm and Community Tree Research Reports. Morrilton, Arkansas, USA, pp 142–150
16. Koskela, J., Vinceti, B., Dvorak, W., Bush, D., Dawsony, I., Loo, J., Kjaer, E.D., Navarro, C., Padolina, C, Borda´cs, S., Jamnadass, R., Graudal, L., Ramamonjisoa, L. (2010). The Use and Exchange of Forest Genetic Resources for Food and Agriculture. Commission on Genetic Resources for Food and Agriculture. Background study paper no. 44. 9th meeting of the Working Group on Access and Benefit-sharing held in Cali, Colombia, 22–28.
17. Koskela, J., Vinceti, B., Dvorak, W., Bush, D., Dawson, I., Loo, J., Kjaer, E.D., Navarro, C., Padolina, C., Borda´cs, S., Jamnadass, R., Graudal, L., Ramamonjisoa, L. (2010). The Use and Exchange of Forest Genetic Resources for Food and Agriculture. Commission on Genetic Resources for Food and Agriculture.
18. Lengkeek, A.G., Jaenicke, H., Dawson, I.K. (2004). Genetic bottlenecks in agroforestry systems: results of tree nursery surveys in East Africa. Agrofor Syst 63(2): 149–155
19. Lillesø, J-PB., Graudal, L., Moestrup, S., Kjær, E.D., Kindt, R., Mbora, A., Dawson, I., Muriuki, J., Ræbild, A., Jamnadass, R. (2011). Innovation in input supply systems in smallholder agroforestry: seed sources, supply chains and support systems. Agrofor Syst 83(3):347–359

20. Matenda, T., Amtaita, T., Mrema, M. (2010). An assessment of the nursery industry in Manicaland, Zimbabwe. Africa University. Faculty of Agriculture and Natural Resources, Mutare, Zimbabwe. Unpublished report
21. Mbora, A., Lillesø, J-PB. (2007). Sources of tree seed and vegetative propagation of trees around Mt. Kenya. Development and Environment No. 9-2007. Forest & Landscape Denmark, p 63
22. Mulawarman Roshetko, J.M., Sasongko, S.M., Iriantono, D. (2003). Tree seed management: seed sources, seed collection and seed handling: a field manual for field workers and farmer. World Agroforestry Centre-ICRAF and Winrock International, Bogor
23. Namoto, M., Likoswe, M.G. (2007). Case studies of nurseries in Malawi. Forest and Landscape. Working paper no. 20. Hørsholm, Denmark
24. Nyoka, B.I., Roshetko, J.M., Jamnadass, R., and Cornelius, J. (2014). *Tree Seed and Seedling Supply Systems: A Review of the Asia, Africa, and Latin America Models.* Small-scale Forestry 14(2): 171-19. DOI: 10.1007/s11842-014-9280-8
25. Place, F., Kindt, R. (1997). The complexities of supply of tree germplasm: the need for policy interventions. In: ICRAF, International Workshop on Policy Aspects of Tree Germplasm Demand and Supply. Proceedings of a workshop organized at ICRAF, Nairobi, Kenya, 6–8 Oct 1997. ICRAF, Nairobi
26. Resources for Food and Agriculture. Commission on Genetic Resources for Food and Agriculture. Background study paper no. 44. 9th meeting of the Working Group on Access and Benefit-sharing held in Cali, Colombia, 22–28 March 2010
27. Roshetko, J.M., Mulawarman Dianarto, A. (2008). Tree seed procurement: diffusion Pathways in Wonogiri and Ponorogo, Java. Small scale for 7(3/4):333–352
28. Roshetko, J.M., Tolentino Jr, E.L., Carandang, W.M., Bertomeu, M., Tabbada, A.U., Manurung, G. and Yao, C.E. (2010). Tree nursery sourcebook. Options in support of sustainable development. Bogor, Indonesia. World Agroforestry Centre (ICRAF), SEA Regional Office and Winrock International opkj.
29. TLC. (2006). Enhancing Rural Livelihoods. In: Annual Report for Malawi, Tanzania, and Mozambique. Total Land Care, Lilongwe, Malawi

Annex I: Data Sources for the Study on Seed and Seedling Supply Systems in Pakistan

S. No.	Name	Designation	Organization
Azad Jammu and Kashmir (AJK)			
1	Mohammad Irtaza Qureshi	DFO/Focal Person REDD+	Forest Department AJK
2	Mir Naseer Ahmed	DFO Reforestation	Forest Department AJK
3	Arshad Khan	Regional Project Director, TBTAP	Forest Department AJK
4	Fouzia Jehan	Manager Seed Centre	Forest Department AJK
5	Ch. Mohammad Rafiq	Assistant Chief, Planning and Development	Forest Department AJK
6	Sardar Mohmmad Rafiq	DFO, Watershed, Poonch – Rawalakot	Forest Department AJK
7	Mr. Naseer Mir	DFO, Watershed, Muzaffarabad	Forest Department AJK
8	Raja Abid Hussain	DFO, Watershed, Bhimber	Forest Department AJK
9	Syed Ghulam Hussain Shah	CCF (Dev)	Forest Department AJK
10	Amjad Yousaf	Computer Operator	Forest Department AJK
11	Dr. Zakir Hussain	DFO Demarcation Poonch	Forest Department AJK
12	Sardar Iftikhar	Conservator Poonch	Forest Department AJK
13	Syed Rashid Hussain Shah	PD TBTAP	Forest Department AJK
14	Shah Nawaz	Farmer/Owner	Sardar Gee Nursery, Dakhri, Kotli
15	Zia-ur-Rehman	Farmer/Owner	Sardar Gee Nursery, Dakhri, Kotli
16	Khalid	Farmer/Owner	Khalid Hussain Nursery, Kaladab, Kotli
17	Saira Illyas	Farmer/Owner	Saira Illyas Nursery, Dawarandi, Hajira, Poonch
18	Muhammad Shaheen RFO (Rtd)	Farmer/Owner	Shaheen Nursery Darra Shair Khan, Poonch
19	Amna Bashir	Farmer/Owner	Amna Bashir Nursery Jatlan, Mirpur
20	Rifat Kousar	Farmer/Owner	Rifar Kousar Nursery New Jabot, Mirpur
21	Muhammad Azeem Khan	Farmer/Owner	Ghail Nursery Komikot, Muzaffarabad
22	Raja Noman Khan	Farmer/Owner	Noman Nursery Kahori, Muzaffarabad
23	Shoib Imtiaz	Farmer/Owner	Sholib Nursery Shahkot, Authmuqam, Neelum Valley
Balochistan Province			
1	Niaz Khan Kakar	Conservator Forest (Quetta)/PFP-REDD+	Forest Department Baluchistan
2	Samiullah Jaffar	Deputy Conservator Forest (Research)	Forest Department Baluchistan
3	Syed Ali Imran	Conservator/Project Director 10BTAP	Forest Department Baluchistan
4	Syed Ghulam Muhammad	Chief Conservator	Forest Department Baluchistan
5	Aslam Buzdar	Conservator/PD TBTAP	Forest Department Baluchistan
6	Hameed Alizai	Manager, South	FAO, Baluchistan
7	Yousaf Kakar	Ex-Chief Conservator	Forest Department Baluchistan
8	Dr. Saadullah Leghari	Chairman Botany Department	University of Baluchistan
9	Bashir Ahmad	Farmer/Owner	Gul Farosh Nursery, Quetta
10	Abdul Sattar	Farmer/Owner	Sharjah Nursery, Quetta
11	Habib Khan	Farmer/Owner	Hanzala Nursery, Mustafa Abad, Quetta
12	Zia Ur Rehman	Farmer/Owner	Zia Garden & Nursery Akhtarabad, Quetta
13	Qasim Shah	Farmer/Owner	Zia Garden & Nursery Akhtarabad, Quetta
14	Sher Ahmad	Farmer/Owner	Khushnood Nursery, Quetta

15	Haji Abdul Manan	Farmer/Owner	Gulshan Nursery Quetta
16	Muhammad Naseer	Farmer/Owner	Guldasta Nursery, Quetta
17	Haji Abdul Qayum	Farmer/Owner	Shehzad Nursery Chiltan, Quetta
18	Muhammad Arshad	Farmer/Owner	Chiltan Nursery, Quetta
19	Asmatullah Agha	Farmer/Owner	Agha Jan Nursery, Quetta
Gilgit Baltistan Province (GB)			
1	Muhammad Essa	Coordinator REDD+	Forest Department, GB
2	Zahid Ullah	DFO	Forest Department GB
3	Majeed Sardar	DFO	Forest Department, GB
4	Gohar Ali Gohar	Range Forest Officer (RFO)	Forest Department, GB
5	Khursheed Alam	RFO	Forest Department, GB
6	Roman Ghayas	RFO	Forest Department, GB
7	Imran Changhazi	RFO	Forest Department, GB
8	Akhtar Riaz	Farmer/Owner	Sajjad Private Forest Nursery, Gilgit
9	Zulfiqar	Farmer/Owner	Zulfiqar Fruit Forest Nursery, Gilgit
10	Abdul Qadir	Farmer/Owner	Abdul Qadir Nursery Ghowari, Ghanche
11	Muhammad Abbas	Farmer/Owner	M. Abbas Nursery, Ghanche
12	Muhammad Shafi	Farmer/Owner	M Shafi Nursery, Ghanche
13	Muhammad Arif	Farmer/Owner	M Arif Nursery, Ghanche
14	Raza Ali	Farmer/Owner	Raza Ali Nursery, Ghanche
15	Muhammad Abdullah	Farmer/Owner	M Abdullah Nursery, Ghanche
16	Muhammad Shuaib	Farmer/Owner	M Shuaib Nursery, Ghanche
17	Shujat	Farmer/Owner	Shujat Nursery Ghazi Thang, Ghanche
18	Muhammad Ali	Farmer/Owner	M Ali Nursery Thong us, Ghanche
19	Ilyas Hussain	Farmer/Owner	Ilyas Hussain Nursery Balghar, Ghanche
20	M. Hussain	Farmer/Owner	M Hussain Nursery Balghar, Ghanche
21	Shair Ali	Farmer/Owner	Shair Ali Nursery Balghar, Ghanche
22	Rustam Ali	Farmer/Owner	Rustam Ali Nursery Balghar, Ghanche
23	Gul Khan	Farmer/Owner	Gul Khan Nursery Balghar, Ghanche
24	Ghulam Hussain	Farmer/Owner	Ghulam Hussain Nursery Sogha, Ghanche
25	Muhammad Sadi	Farmer/Owner	M Sadi Nursery Talis, Ghanche
26	Abdul Haleem	Farmer/Owner	Abdul Haleem Nursery Balghar, Ghanche
27	Serwar Ali	Farmer/Owner	Serwar Ali Nursery Talis, Ghanche
28	M. Hassan	Farmer/Owner	M Hassan Nursery Talis, Ghanche
29	M. Baiqar	Farmer/Owner	M. Baiqar Nursery Saling, Ghanche
30	Haji Anayat	Farmer/Owner	Haji Anayat Nursery Ghowari, Shigar
31	Ghulam Mehdi	Farmer/Owner	Ghulam Mehdi Nursery Hasopi, Shigar
32	Haji Mehdi	Farmer/Owner	Haji Mehdi Nursery Hurchu, Shigar
33	Haji Ibrahim	Farmer/Owner	Haji Ibrahim Nursery, Shigar
34	Altaf	Farmer/Owner	Altaf Nursery, Ghizer
35	Ahsan Aman	Farmer/Owner	Ahsan Aman Nursery Thing, Ghizer
36	Sadiq Rashmal	Farmer/Owner	Sadiq Rashmal Nursery Sherqilla, Ghizer
37	Shulja	Farmer/Owner	Shulja Nursery Iskoman, Ghizer
Khyber Pakhtunkhwa Province (KP)			
1	Muhammad Arif	DCCF	Forest Department, KP
2	Gohar Ali	DFO, Focal Person REDD+	Forest Department, KP
3	Syed Tariq Ali Shah	DFO/DCF	Forest Department, KP
4	Farzana	SCO	FSCRD Peshawar
5	M. Ibrahim Khan	Deputy Director 10-BTTP	Forest Department, KP
6	M. Bilal Zia	Forest Geneticist	PFI Peshawar
7	Inayathullah Khan	Regional Director FSCRD	FSCRD Peshawar
8	Dr. Sher Muhammad	Biotechnologist	Tissue Culture Lab, KP
9	Dr. Waqas Ahmad	Horticulturist	Tissue Culture Lab, KP
10	Dr. Shah Sawar	Rtd. Research Officer	Tissue Culture Lab, KP
11	Dr. Gul Sanat Shah Khattak	Director	NIFA Peshawar
12	Fayyaz	Farmer/Owner	Fayyaz Nursery Farm, Mardan

13	Sajjad Hussain	Farmer/Owner	Noordaad Khan Nursery, Mardan
14	Huzaifa	Farmer/Owner	Huzaifa Nursery Farm, Mardan
15	Muhammad Asif	Farmer/Owner	Awais Nursery and fruit Farm, Mardan
16	Shakeel	Farmer/Owner	Shakeel Nursery Farm, Mardan
17	Sheraz	Farmer/Owner	Pak Kashmir Nursery Farm, Mardan
18	Waseem Rehman	Farmer/Owner	Faisal Nursery, Haripur
19	Uzair	Farmer/Owner	Mehraj Nursery Farm, Haripur
20	Shaukat	Farmer/Owner	Chanzeb Nursery Farm, Haripur
21	Zubair Ahmad	Farmer/Owner	Mehak Nursery Farm, Haripur
22	Wajid	Farmer/Owner	Pakistan Nursery Farm, Haripur
23	Muhammad Suleman	Farmer/Owner	Gujar Nursery Farm, Haripur
24	Sajjad Ahmad Awan	Farmer/Owner	Sajjad Nursery Farm, Peshawar
25	Hastam	Farmer/Owner	Gulshan Iqbal Nursery, Peshawar
26	-	Farmer/Owner	Pak Sarhad Nursery Farm, Peshawar
27	Shahid Ali	Farmer/Owner	New Tarnab Nursery farm, Peshawar
28	Shaheen Afridi	Farmer/Owner	Afridi Nursery Farm, Peshawar
29	M. Asif Awan	Farmer/Owner	Aawan Nursery Farm, Peshawar
Punjab Province			
1	Iftikhar-ul-Hassan Farooqi	Director Forest Service Academy/ REDD+	Forest Department Punjab
2	Gul Noor Khan Khattak	Director PFRI, Faisalabad	Forest Department Punjab
3	Kamran Babar	DFO Headquarters	Forest Department Punjab
4	Malik Salim	DFO Extension	Forest Department Punjab
5	Faisal Haroon	Chief Conservator Extension	Forest Department Punjab
6	Muhammad Ali Butt	DFO Extension	Forest Department Punjab
7	Anwarul Haq	DFO PFRI	Forest Department Punjab
8	Dr. Anwar Ali	Director Research, PFRI	Forest Department Punjab
9	Muhammad Raza	Sub Divisional Forest Officer (SDFO)	Forest Department Punjab
10	M. Musa	Range Forest Officer (RFO)	Forest Department Punjab
11	Kashif Shehzad Qureshi	RFO	Forest Department Punjab
12	Asad Khalil	RFO	Forest Department Punjab
13	M. Umair	RFO	Forest Department Punjab
14	M. Salik	RFO	Forest Department Punjab
15	Saqib	RFO	Forest Department Punjab
16	Abdul Karim	Farmer/Owner	Green Pakistan Nursery Farm, Multan
17	Haq Nawaz	Farmer/Owner	Choudary Nursery Farm, Multan
18	Irshad	Farmer/Owner	Irshad Nursery Farm, Muzaffargarh
19	Rana Jehanzab	Farmer/Owner	Rana Jehanzab Nursery Farm, Muzaffargarh
20	Muhammad Ashraf	Farmer/Owner	Choudary Nursery Farm, Muzaffargarh
21	Fayyaz Hussain	Farmer/Owner	Fayyaz Nursery Farm, Layyah
22	Sajjad Hussain	Farmer/Owner	Sajjad Hussain Nursery, Layyah
23	Imam Baksh	Farmer/Owner	Chenab Nursery Farm, Layyah
24	Khadim Hussain	Farmer/Owner	New Chenab Nursery farm, Layyah
25	Haseeb Ahmad	Farmer/Owner	Layyah Nursery Far, Layyah
26	Ijaz Hussain	Farmer/Owner	New Model Nursery Farm, Layyah
27	Khadim Hussain	Farmer/Owner	Bismillah Maqbool Nursery Farm, Layyah
28	Irfan Ahmad	Farmer/Owner	Rose Paradise Nursery Farm, Layyah
29	Ijaz Ahmad	Farmer/Owner	Al-Madina Nursery Farm, Layyah
30	M. Fazil Ashraf	Farmer/Owner	Fazil Bhai Nursery, Pattoki
31	Bilal Ashraf	Farmer/Owner	Ashraf Nursery Farm, Pattoki
32	Muhammad Iqbal	Farmer/Owner	Ch Ashraf Nursery Farm, Pattoki
33	Mobin Ali	Farmer/Owner	Kehkashan Nursery Farm, Pattoki
34	Muhammad Imran	Farmer/Owner	Kehkashan Nursery Farm, Pattoki
35	Haji Shoukat	Farmer/Owner	Evergreen Nursery Farm, Pattoki
36	Muhammad Younas	Farmer/Owner	MaashaAllah Nursery Farm, Pattoki

37	Salman	Farmer/Owner	Changa Nursery Farm, Pattoki
38	Shahid Sharif Haidar	Farmer/Owner	Baghban Changga Sarkar Nursery, Kasur
39	Muhammad Ali	Farmer/Owner	M.Ali Nursery Farm, Kasur
40	Muhammad Asif	Farmer/Owner	Aslam Nursery Farm, Kasur
41	Sohail Mushtaq	Farmer/Owner	Asim Nursery Farm, Kasur
42	Muhammad Wasim	Farmer/Owner	Wasim Nursery Far, Kasur
43	Rana Anwar	Farmer/Owner	Rana Anwar Nursery Farm, Kasur
44	Farhan Raza	Farmer/Owner	Grower Plantation, Kasur
45	Usman Haidar Lashari	Farmer/Owner	Lashar Farming Grower, Kasur
46	Noor Muhammad	Farmer/Owner	Noor Nursery Farm, Kasur
47	Muhammad Naeem	Farmer/Owner	Hassan Nursery Farm, Kasur
Sindh Province			
1	Shehzad Sadiq Gill	DFO Coastal Division Karachi	Forest Department Sindh
2	Riaz Wagan	CCF Mangroves, Focal Person REDD+	Forest Department Sindh
3	Abdus Sattar Khatri	Conservator	Forest Department Sindh
4	Abid Hussain	DFO	Forest Department Sindh
5	Tahir Latif	DFO	Forest Department Sindh
6	Habib Ullah Nizami	CCF, Social Forestry	Forest Department Sindh
7	Rizwan Khan	Research Officer	Tissue Culture Lab ICCBS, Karachi
8	Farkhanda Nizam	Research Associate	Tissue Culture Lab ICCBS, Karachi
9	Asma Javaid	Research Associate	Tissue Culture Lab ICCBS, Karachi
10	Kashif Ahmad	DFO	Forest Department Sindh
11	Doda Khan	Range Forest Officer (RFO)	Forest Department Sindh
12	Muhesh Kumar	RFO	Forest Department Sindh
13	Kashif Hussain	RFO	Forest Department Sindh
14	Mehboob Majidano	RFO	Forest Department Sindh
15	Muhammad Azam	Farmer/Owner	Jaffer Nursery Farm, Karachi
16	Ahsan	Farmer/Owner	Ali Raza Nursery Farm, Karachi
17	Irfan Ali	Farmer/Owner	New Karachi Nursery Farm, Karachi
18	Muhammad Musab	Farmer/Owner	City Green Farm, Karachi
19	Khurram Shehzad	Farmer/Owner	Mahi Nursery, Karachi
20	Sajid	Farmer/Owner	Q Shoe Nursery Farm, Karachi
21	Muhammad Raja	Farmer/Owner	Daata Nursery Farm, Karachi
22	Nasir Mahmood	Farmer/Owner	Model Green Nursery Farm, Karachi
23	Shahzaib	Farmer/Owner	Roshan Ali Nursery Farm, Hyderabad
24	Imran Ali	Farmer/Owner	Allah Tawakul Nursery Farm, Hyderabad
25	Mubarik	Farmer/Owner	Barkat Nursery Farm, Hyderabad
26	Haris	Farmer/Owner	Umer Nursery Farm, Hyderabad
27	Mushtaq Rajpoot	Farmer/Owner	Rabia Nursery Farm, Hyderabad
28	Dilawar	Farmer/Owner	Dilawar & Mushtaq Nursery, Hyderabad
29	Irfan	Farmer/Owner	Taj Nursery, Hyderabad
30	Gulfam	Farmer/Owner	Gulfam Nursery, Hyderabad
31	Victor	Farmer/Owner	Baba Laal Nursery, Hyderabad
32	Muhammad Tawab Khan	Farmer/Owner	Al-Madina Nursery Farm, Hyderabad
33	Awais	Farmer/Owner	Awais Nursery Farm, Sukkur
34	Abdur Rehman	Farmer/Owner	Pak Bahria Nursery farm, Sukkur
35	Shakeel Ahmad	Farmer/Owner	Bismillah Nursery Farm, Sukkur
36	Nasrullah	Farmer/Owner	Pak Azad Nursery Farm, Sukkur
Islamabad (Capital Territory)			
1	Dr. Sadar Uddin Siddiqui	Chief Scientific Officer	Bio Resource Conservation Institute, Plants Genetic Resources Programme (PDRP), Islamabad
2	Muhammad Umer Farooq	Principal Scientific Officer	Rangeland Research Institute, Islamabad
3	Ahsan	Farmer/Owner	Ahsan Azad-PK Farms, Islamabad
4	Fateh Muhammad	Farmer/Owner	Fateh Muhammad Nursery, Islamabad
5	-	Owner	Green Impex Seed Store, Islamabad

Consultation, data collection and technical exchange on seed and seed orchard management			
1	Gul Noor Khan Khattak	Director PFRI, Faisalabad	Punjab Forest Department
2	Syed Nadeem Bukhari	Team Leader	Helvetas Pakistan
3	Abdus Sattar Khatri	Conservator	Sindh Forest Department
4	Syed Tariq Ali Shah	DFO/DCF	KP Forest Department
5	Muhammad Essa	REDD+ FC	GB Forest Department
6	Abid Hussain	DFO	Sindh Forest Department
7	Tahir Latif	DFO	Sindh Forest Department
8	Farzana	SCO	FSCRD
9	Zahid Ullah	DFO	GB Forest Department
10	M. Ibrahim Khan	Deputy Director 10-BTTP	KP Forest Department
11	M. Bilal Zia	Forest Genetist	PFI Peshawar
12	Inayathullah Khan	Deputy Director FSCRD	FSCRD Peshawar
13	Muhammad Irtaza Qureshi	DFO	AJK Forest Department
14	Syed Ghulam Muhammad	Chief Conservator	Balochistan Forest Department
15	Dr. Arjumand Nizami	Country Director	Helvetas Pakistan
16	Munawar Khan	Team Leader	Helvetas Pakistan
17	Irshad Ali	Communication Officer	Helvetas Pakistan
18	Kamran Babar	DFO Headquarters, Chief Conservator Forest – 1	Punjab Forest Department
19	Malik Salim	DFO Extension	Punjab Forest Department
20	Faisal Haroon	Chief Conservator Extension	Punjab Forest Department
21	Muhammad Ali Butt	DFO Extension	Punjab Forest Department
22	Anwar ul Haq	DFO, Punjab Forest Research Institute	Punjab Forest Department
23	Dr. Anwar Ali	Director Research	Punjab Forest Research Institute, Punjab Forest Department
24	Fouzia Jehan	Manager Seed Center	AJK Forest Department, Muzaffarabad

Annex 2: Cost benefit calculator

Total Annual Production / Variation Costs - Islamabad			
Description	**Unit (Kanal)**	**Unit Cost (Rs)**	**Total Cost (Rs)**
Land Lease Cost (If applicable)	4	25000	100000
Land Preparation		10000	10000
Seeds Cost (Lum Sum)		20000	20000
Polybags procurement		30000	30000
Chemical fertilizer		5000	5000
Compost/Farmyard Manure		5000	5000
Pesticides		5000	5000
packing/Shipping material			
Transplanting (Lum Sum)		70000	70000
Seed sowing (Lum Sum)		70000	70000
Seedling maintenance (1 cycle)		180000	180000
Application of pesticides, herbicides fertilizer, irrigation etc		10000	10000
Harvesting			
Water expenses		150000	150000
Fuel expenses (Machinery)			
Electricity expenses		36000	36000
Daily Wage Labour			
Full Time Staff Salaries			
Repair and maintenance			
Transportation Expenses			
Fencing		100000	100000
Sweet soil and sand		20000	20000
Miscellaneous Expenses		50000	50000
Grand Total (Rs)			**861000**
Per unit production cost = Total Production cost/ Total number of units produced			**100000**
Per unit production cost = 861000/100000=8.61 Hence it shows that the total cost incurred per seedling is 8.61 Pakistan rupees.			**8.61**
Key Informant = Mr. Hammad Satti, Assistant Director, CDA			
No of Seedling Produced = 100000			

PROVINCE	SPECIES
Islamabad	Kachnar (*Bauhinia variegata*)
	Amaltas (*Cassia fistula*)
	Willow (*Salix babylonica*)

FOREST TREE SEED CERTIFICATION STANDARDS (1988)

I. Application and Amplification of General Certification Standards

A. The General Seed Certification Standards, as adopted by Federal Seed Certification and Registration Department (FSCRD) are basic and together with the following specific standards constitute the standards for certification of forest tree seed.

B. Section V of the General Standards is amplified as follows to apply specifically to forest tree seed.

1. Certified Tree Seed (Blue Tag)
   Certified seed shall be seed from trees of proven varietal superiority, as defined by the following standards, produced so as to assure varietal identity (Seeds from inter-specific hybrids of forest trees may be included.) In addition, the following subclass may be acceptable for certification.

   a. Selected Tree Seed (Green Tag)
      Selected tree seed shall be seed from untested parentage of rigidly selected trees or stands that have promise but no proof of genetic superiority.

   b. Source-Identified Seed (Yellow Tag)
      Source Identified seed may be from natural stands including seed production areas with known geographic origin plantations of known provenance. The source is to be identified to county or counties of collection and must meet the standards of Section V.c.

2. For all classes of forest tree seed, the exact geographic source of the parent trees and the stand history must be known. Location of the source of certified and selected tree seed shall be designated by section or comparable land survey unit. Location of source identified tree seed shall be defined by means of administrative and geographic boundaries and, where applicable, by altitudinal and other appropriate boundaries judged to be significant by the certifying agency.

II. Land Requirements

Elevation to the nearest 250 feet of the original geographic source on mountain collection only and site index (50 years) shall be specified on application and the tag.

III. Field Inspections

A. An initial field inspection must be made at least 21 months prior to seed collection. A second inspection must be made within 90 days prior to cone collection. During the second inspection the inspector will make an estimated count of cone production. Not required for source identified seed (yellow tag). Source identification accepted on notarized statement of collector.

B. Inspections will be required only in years in which certified seed production is planned after the initial inspections, provided that subsequent inspections shall be not more than 5 years apart. Not required for source identified seed (yellow tag). Source identification accepted on notarized statement of collector.

C. Inspections may be made at any time during cone collection, seed extraction and cleaning without prior notice.

IV. Field Standards

A. General

1. Definitions

The term cone shall include the seed contained therein. The term scion shall include all materials for vegetative propagation of a clone.

2. Unit of Certification.

An area or a portion of an area may be certified. The portions of an area not meeting certification requirements shall be delineated with a painted boundary mark (colour contrasting with other boundaries) and cones produced on the disqualified area may not be collected. A clear and distinct boundary line will be marked with paint between an area and its isolation strip. The outer boundary of the isolation strips shall be marked with a contrasting colour or symbol. None required for source identified seed. (Yellow tag).

3. Isolation Requirements

A minimum isolation distance of 400 feet shall be provided for all species of pine for certified tree seed (blue tag) and selected tree seed (green tag). None required for source identified seed (yellow tag).

4. Nursery inspections and control for the production for certified seedling

B. Procedures for Sowing Seed

a. Only certified seed will be used.
b. A map shall be made that shows the exact location in the nursery where each certified seed lot is sown, the area sown to each lot and the sowing rate shall be recorded.

C. Procedures for Lifting, Grading and Packaging of Certified Seedlings

a. An inventory of the number of seedlings produced from each lot of certified seed sown shall be made prior to lifting and reported in writing to concerned authorities.
b. Only seedlings from beds identified according to IV. A. 4. A. b. shall be lifted, graded, and tagged as Certified Seedlings. Systematic procedures are to be adopted that will insure, that no mixing of seedling lots occurs in the packing shed.
c. Not more than 2,000 trees may be packed in a single bundle. The approximate number of seedlings per bundle and the number of bundles tagged shall be recorded. Total number of seedlings shipped shall not exceed five percent of the prelifting inventory.

D. Specific Requirements

Seed Producing Areas

a. Stand Selection

The stand must initially contain a minimum of one-hundred (100) trees per acre of the desired species that are at least 10.0 inches D. B. H., or a minimum basal area of 50 sq. feet. The stand shall be even aged and shall not have been previously thinned except where a record is available to show that thinning was from below.

b. Stand Treatment

1. Roguing

All rust infected (Cronartium fusiforme and c. cerebrum) trees, excepting cone rusts, area to be cut and removed from the area. All trees of below average vigor (growth rate) and form must be removed. All trees having above average branch size must be cut. All trees having spiral stems or forks must be removed.

2. Stand Composition

Only trees of average or above vigor and form, and average or below in branch size, and free from pests shall remain.

3. Isolation Strip

The area shall be free of contaminating pollen. An isolation strip shall be maintained. A strip 400 feet wide adjacent to the production area shall be free of all species of trees which will normally cross pollinate naturally with the species of the production area, except that this strip may contain trees of the same species providing that it meets the standards of roguing and stand composition of the production area.

4. Seed Orchards

i. Stand Composition: The stand will be composed of at least 15 clones of trees. The identity of each tree shall be known and records of the ortet (or parentage in the case of seedling stock) shall be unavailable for inspection. The arrangement shall be such as to maximize crosspollination between clones.

ii. Progeny Tests: All clones in a seed orchard must be progeny tested and approved before Certified Tree Seed (Blue Tag) may be produced. The records of each progeny test shall be retained available for records to proper authorities for evaluation.

iii. Certification: Prior to completion of progeny test and qualification for Certified Tree Seed, seed which are produced in seed orchards may be sold as Selected Tree Seed (Green Tag) provided that all ortets or individual trees qualify as plus trees.

iv. Isolation: minimum of 400 feet surrounding the orchard shall be free of all trees producing contaminating pollen.

5. Seedling Seed Orchards

i. Stand Composition: The stand shall be composed of the progeny of at least 15 trees qualifying as plus trees. The stand shall have been rogued at least to the level required for seed producing areas. (Sec. B. 1. b.)

ii. Progeny Tests: Seedling seed orchards must be progeny tested and approved before certified tree seed (blue tag) can be produced. Seedling seed orchards may be progeny tested by any of the methods acceptable for seed producing areas or clonal seed orchards. The records of each progeny test shall be available for records to proper authorities for evaluation.
iii. Certification: Prior to completion of progeny tests and qualifications for certified seed, seed which are produced in seedling seed orchards may be sold as Selected Tree Seed (Green Tag) provided that no single progeny line shall constitute more than 30% of the stand.
iv. Isolation: A minimum of 400 feet surrounding the orchard shall be free of all trees producing contaminating pollen.

6. Elite Trees (Including Varieties)

i. Individual Characteristics: A tree must possess certain characteristics such as superior growth, gum yield, specific gravity, etc. which can be described and must be capable of being differentiated from other trees of the same species on the same site.
ii. Progeny Tests: All trees must be progeny tested before certification. The progeny tests and records shall be handled as to seed orchard clones.
iii. Certification: Open pollinated seed may be labelled Selected Tree Seed (Green Tag) if a 400-foot isolation strip is rogued of all diseased and defective trees (seed producing area standards). Controlled pollinated seeds may be labelled Certified Tree Seed (Blue Tag) provided the cross presented for certification has been progeny tested.
iv. Identification: Each tree shall be marked with a band of paint not less than 6 in. wide containing identifying numbers and/or letters. The records for each tree shall contain a complete description of the tree and a map showing its exact location.

V. Seed Standards

A. Germination Tests
Tests will be acceptable only from laboratories approved by FSCRD. Tests must have been completed within 9 months prior to shipment of seed and the seed must have been stored in air-tight moisture proof containers at moisture content less than 10% and temperature below 36 degrees F. from the time of sampling until shipment

B. Lot Size
No lot of tree seeds may contain more than 1,000 kg.

C. Specific requirements for minimum germination standards may be determined within the respective provincial Forest department for specific species of sub national relevance.

INSTRUCTIONS & PROCEDURES

1. Seed house or inspection of seed: Seed and/or cones should be so handled as to prevent mixture and maintain identity. Each lot of cones or seed shall be identified at all times throughout processing.

2. Cone Drying: Lots of cones shall be isolated in drying by seed proof barriers to prevent mixing of seed as the cones open. All drying racks, areas, etc. shall be thoroughly inspected and cleaned prior to use. All cone and seed handling machinery shall be inspected and cleaned prior to use. The amount of clean seed obtained from each orchard, which requested inspection, will be reported by the seed plant.
3. Off type trees must be marked at the time of inspection and felled while the inspector is in the area. If these trees are felled at a later date, a reinspection will be required.
4. Crook will be acceptable in trees only if it is mechanically accountable. Where a majority of trees in a stand have a similar crook at approximately the same height, this can be assumed to be mechanical.
5. Sweep will be acceptable if it occurs in one place only and deviates from a line from the centre of a 4-inch merchantable top to the outside of the butt; NOT MORE THAN ONE INCH FROM EACH TEN FEET IN TOTAL HEIGHT.
6. In order to provide pollen, it is desirable to leave the maximum number of acceptable trees on the isolation strip.
7. For source identified seed (yellow tag) the bushels of cones will be reported immediately following collection on the notarized statement and the amount of clean seed will be reported with request for tags.

Annex 4: Draft Guidelines for Identification, Establishment and Management of Forest Seed Orchards and Seed Quality Assurance at the National and Subnational level

Preamble
These guidelines have been prepared under the auspices of "The Seed (Amendment) Act 2015" Government of Pakistan for improved quality of seed management in forestry sector of Pakistan through quality assurance in identification, establishment, and management of forest seed orchards and seed collection.

These protocols have been prepared under the coordinated technical deliberation between Federal Seeds Certification and Registration Department, Government of Pakistan (FSCRD), Pakistan Forest Institute (PFI), jointly with Forestry, Wildlife and Fisheries department State of Azad Jammu & Kashmir (**AJK);** Forest and Wildlife department **Balochistan;** Forest, Parks and Wildlife department **Gilgit Baltistan**; Forestry, Environment and Wildlife department Khyber Pakhtunkhwa **(KP);** Forest Wildlife and Fisheries department **Punjab; and, Sindh** Forest department.

Title
These guidelines are called Identification, Establishment and Management of Forest Seed Orchards and Seed Quality Assurance"

Applicability
These guidelines are relevant for all the initiatives meant to establishing seed orchards for multiplication of forest tree species at national and subnational level as well to guide quality assurance of seed collected by private entities and procured by the public sector entities. These guidelines are legally binding for all government organisations dealing with forest tree germplasm management and are meant for improving forest tree germplasm in Pakistan.

Definitions

Seed Orchards: *A seed orchard is an intensively managed plantation of specifically arranged/ identified trees for the mass production of genetically improved seeds to create plants, or seeds for the establishment of new forests. Seed orchards are stands planted specially to produce abundant superior seeds. A seed orchard consists of trees where the phenotype is usually of minor importance as long as the trees will produce seeds.* http://www.fao.org/3/ad223e/AD223E05.htm Seed stands or plus trees will be identified, morphological characteristics will be documented and registered. This will be done by the technical committee comprising of forest expert, genetic expert and FSCRD representative.

Seed: *Seed means any of the branded reproductive or vegetative propagating materials of the plants of field crops, vegetables crops, fruits, spices, medicinal herbs, flowers, shrubs, forest trees, other species and mushroom spawn used for sowing or planting the genera or species prescribed by the Federal Government.* **Section 12, Clause xxiii,** The **Seed (Amendment) Act 2015** of the Federal Government. The list of the forest tree species will be updated from the Khyber Pakhtunkhwa Forest Ordinance 2002 and the similar updating of the list is applicable for other provinces.

Types of seed orchards: There are two main types of seed orchards, named according to the way of establishment:
1. *Clonal Seed Orchard: Seed orchard raised from selected clones propagated by grafting, cutting, air-layering or tissue culture.*
2. *Seedling Seed Orchard: Seed orchard raised from seedlings produced from selected parents through natural or controlled pollination.* http://www.fao.org/3/ad223e/AD223E05.htm

Certification authority:
Federal Seed Certification and Registration Department (FSCRD) provides quality control cover through registration of crop and tree variety, crop and tree inspection and seed testing. This system is being implemented at federal level under the Seed Act, 1976.

Guidelines

1. Identification of Seed Orchard.
Initially to establish the certified/ quality seed production system in forestry sector, seed stands/ plus trees will be identified through Truth & Labelling method from the existing sources.

i. The size of the seed orchard is determined by the seed demand and the expected seed production from the orchard. A seed orchard may in theory be operative if the trees are physiologically capable of producing seeds. In practice, however, a seed orchard will only be operative until a new improved seed orchard has been established.
ii. The seed stand must initially contain a minimum of one hundred (100) trees per acre of the desired species that are at least 10.0 inches D.B.H., or a minimum basal area of 50 sq. meter.
iii. The stand shall be even aged and shall not have been previously thinned except where a record is available to show that thinning was from below.
iv. Seed Stand Composition: Only trees of average or higher form and vigour, shall remain in the Stand Composition.

v. **Criteria for seed trees** differs for the objective of seed selection and multiplication

- **Timber tree criteria**
  - Above average tree height and stem diameter
  - Straight stem form
  - Long, clear merchantable bole
  - Uniform crown, without heavy branches or double stem
  - Free of pests and diseases
  - Good quality timber
  - Mature tree that produces ample quantities of seed
- **Fodder trees and living fences**
  - Rapid growth
  - High leaf production
  - High nutritive values of leaf
  - Good coppicing ability
  - Tree stature and shape that fits the intended planting system and site
  - Free of pests and diseases
  - Drought resistance
  - Mature tree that produces ample quantities of seed
- **Fruit trees**
  - Good growth
  - Abundant, sweet, and big fruits – depending upon what is needed.
  - Uniform crown with low branches
  - Free of pests and diseases
  - Mature tree that produces ample quantities of seed

2. Establishment of Seed Orchards:

Seed stands/ plus trees will be a property of forest Department in each ecological zone and forest Department will be responsible for management.

i. Location of seed orchards: Since the seed orchard is planted entirely to produce seeds, the conditions in which it is grown should benefit flowering and fruiting. Selection of the appropriate site for the seed orchard will ease the management during and after the establishment.
ii. Site preparation and establishment of orchards. The plants (either vegetative propagated or seedlings) are vulnerable to competition from weeds, to fire, diseases, browsing, termites, etc. during the first year of establishment. The better the site is prepared before planting, the easier the future management.
iii. Clearing: Left woody material may attract pests, diseases, increase the risk of fire and impede mechanical management. The ideal one is a completely cleared area, free from trees, shrubs, stumps, and big stones. That will ease the access to the area and mechanical operation. If the seed orchard is established on forest land, all trees and shrubs should be cut and removed or burned on the site.
iv. Soil Preparation: Proper soil preparation improves the growth of the tree plants and promotes their competition with other plants. The site should be completely weeded before planting by ploughing and harrowing. Mechanical cultivation improves soil structure, and consequently water holding capacity and draining. A hardpan impedes draining. Hardpan is broken by deep ploughing or sub-soiling. The soil should have the optimal acidity and nutrient level for the tree species to be planted. Soil tests are carried out prior to planting. Possible lime and fertilizer are applied before planting.

Weed control can be facilitated by proper soil preparation. Several mechanical cultivations promote weed seed germination. Germinated seedlings are then destroyed by mechanical cultivation

v. Establishment of pollen dilution zones (PDZ): Cleared areas are established between the seed stand and possible contaminating sources. The PDZ is a zone where trees of the same species and species that can hybridize with the species are removed. The wideness depends on the species and pollination pattern. The zones also serve as firebreaks. For wind pollinated species a short vegetation of the PDZ is desired, usually 200–400 meters, depending on species and wind exposure, however, a minimum of 400 feet (about 120 meters) surrounding the orchard shall be free of all trees producing contaminating pollen. If there is a prevailing wind during the pollination period, the width of the PDZ may be diminished from the other sides. For insect-pollinated species the width and the vegetation of the PDZ depends on the behaviour of the pollinator.
vi. Promotion of pollination: Promotion of the pollination is easiest for wind-pollinated species. Spacing is a method of improving the condition for wind pollination. The effect on insect-pollinated species is probably different from species to species according to pollinator, but details are poorly known. Promoting pollination by insects by putting up beehives is widely used in fruit orchards and agriculture and is applicable to seed orchards in forestry.
vii. Demarcation of plots and rows: The orchard design is clearly demarcated. Replications, blocks, and plots should be distinctly demarcated. The corners should be marked with conspicuous persistent poles / signs indicating necessary details. The material and way of putting up should be so that it will be difficult to be removed or stolen.
viii. Demarcation of pits and pitting: Follows the normal silvicultural practices. A final spacing in seed orchards of 10 meters is reasonable for most species to allow free crown development. Depending on the expected thinning the initial spacing may be 2–6 meters.
ix. Planting: Normal silvicultural practices. Extra care should be taken with grafted and budded material since the grafting or budding site may still be vulnerable. Sometimes the root stock is planted in the field before grafting and consequently carried out in the field. The planting usually involves several clones or families, and it is important that the planting is done according to a prescribed plan so that the identity of the individual tree is clear. Appropriate measures should be taken to avoid confusion/mixing up of the plants.
x. Beating up: Correct replacement of dead seedlings is crucial. If wilted, seedlings or grafted plants are replaced, and care should be taken that the replacement will not disturb the orchard design, i.e., plants should be replaced with the same clone / family.
xi. Cover crops: A temporary legume cover crop may be planted between the tree plants. The cover crop is beneficial to the soil (legumes fix nitrogen) and may facilitate weed control and diminish erosion.

3. Sylvicultural management of seed orchards

i. Special care should be given to the plants during the first year of establishment during which they are vulnerable.
    1. Weeding: The plants should be kept from weed competition during establishment. Complete weeding should be done at least around each plant. Weeds between the plants may be cut or completely removed. If chemical weeding is applied, care should be taken in terms of time, weather condition, and doses of application.
    2. Rouging: Once the result of the progeny test is available, the undesired families or ramets are cut and removed.
    3. Thinning and pruning: In addition to rouging, the trees may be thinned, and the branches systematically pruned to make an open crown with large flower production and facilitate seed harvest.
    4. Fertilization and watering: Water and fertilizer should be applied whenever necessary to give the trees optimal growth conditions. Conditions are especially important during flowering and fruit development. The amount and type of fertilizer differs from species to species.
    5. Flower induction: If flowering fails or is unsatisfactory, it may be induced or promoted by (1) imposing stress or (2) applying flower inducing hormones during flower differentiation.

ii. Imposing stress: Various methods of stress-imposing promote flowering:
    - Water stress can be imposed if water availability can be manipulated by artificial watering or irrigation. A brief drought during floral differentiation will usually induce flowering. The watering should be re-continued after flowering.

- Hormone application: The active hormone in flower differentiation is gibberellin. Artificially manufactured versions of the hormone are sold under various trade names. Hormones can be applied by spraying flowering branchlets with the remedy or by applying to the cambium.

4. Seed management

Forest department jointly with FSCRD will start from classified seed production which will lead to certified seed production once the seed orchards/ plus trees specie wise get registered with FSCRD.

A. Seed has three different categories in forestry sector:
   - Unclassified seed – seed collected from unknown sources, and nothing known about the seed source/ origin etc and used for raising the nursery.
   - Classified seed – only location and specie of the plants are known from which the seed is collected. Generally, the local forest department collect seed and either provide to PFI or to the departments for raising nursery.
   - Certified seed – where all procedures are followed like breeder, ecology, time of seed collection is known, type and tree population are known, proper germination tests are carried out before sowing in the nursery etc. However, the use of certified seed for raising nursery in forest don't exist.

B. Good quality seed is defined as varietally pure with a high germination percentage, free from diseases and disease organisms, and with a proper moisture content and weight. Quality seed ensure good germination, rapid emergence, and vigorous growth. These aspects translate to a good stand in the field and green house. Quality seed must be high in germination, relatively free from insect or mechanical damage, pure for the crop variety, and contain little or no inert matter or weed seeds.

C. Characteristics of good quality seed include the following:
   - Higher genetically purity.
   - Higher physical purity for certification.
   - Possession of good shape, size, colour, etc., according to specifications of variety.
   - Higher physical soundness and weight.
   - Higher germination (90 to 95 % depending on the crop/ tree)
   - Higher physiological vigour and stamina.

D. Using good quality seeds leads to lower seed rate, better emergence (>70%), more uniformity, less replanting, and vigorous early growth which helps to increase resistance to insects and diseases and decrease weeds.

5. Seed collection methods

i. After selecting and marking good mother trees, several seed collection methods can be used.
   - **Collecting from natural seed fall:** This is the simplest way to collect seed. It does not require skilled labour. Collection from natural seed fall is suitable for trees with large fruits, pods, and seeds. For collecting seed from natural fall, follow these steps:
     a. Clear the ground beneath the tree of leaves, branches, and weeds before seeds begin to fall. This will make seed collection easier or spread plastic sheets, cloth, or canvas under the mother trees so that the seeds will fall onto them.
     b. Use a rack to gather the seeds and collect them daily or fold sheets to collect seeds daily. Chances of insect attack and fungal infection which could occur if seeds are left on the ground too long will be minimized.
     c. Extract seeds from the litter by sieving

   - **Collecting seeds from the ground fall has some disadvantages:**
     a. Some seeds may have fallen from the tree immaturely.
     b. There is greater potential for insect attack and fungal infection.
     c. Seeds left on the ground for a long time often lose viability or start germinating.

ii. Shaking the tree: If natural seed fall is spread over a long period of time, manual shaking of the tree is a useful method to get seeds to fall to the ground at the same time. This makes their

collection easier. In some cases, however, fruits or pods are strongly attached to the branches and will not drop off easily, even when the tree is shaken. If this is the case, other methods will need to be used.

- Clean the ground or lay down a plastic or canvas sheet.
- Shake the trunks of trees or low branches by hand. (Higher branches may be shaken using a stick, long pole, hook on rope).
- Separate seed from the dry pods

iii. Sometimes, seed bearing branches will be low enough to allow the collector to bend branches over collection sheets and release the seeds onto the sheet. (Use thick leather gloves when branches are thorny).

iv. Pruning of seed-bearing branches: When the seed is out of reach for hand picking, various pole implements may be used for pruning branches.

- Select branches with a heavy load of good-looking pods.
- Carefully locate the ground sheets so that pods and seeds will fall onto them from pruned branches.
- If necessary, prune out "windows" so that seed bearing branches can fall to the ground and not get entangled in the tree as they fall.
    1. Cut the branches.
    2. Collect the pods.
    3. Remove the seeds.

v. To use is method, it is essential in acquire appropriate tool including:

- A special pole pruner with shears attached
- A long pole with a saw or hooked knife attached
- Light, rigid bamboo, aluminium, or plastic poles 4–6 meters in length may also be used.
- A hooked branch can substitute if the other tools are unavailable.

vi. Throwing a rope with weighted end to break off a seed-bearing branch: As the last possibility this destructive method may be used to reach high seed-bearing branches from the ground, without having to climb the tree. Branches up to 12 meters from the ground can be reached. Skill is required to throw the rope over the selected branch and in the correct position for ease of breakage.

- Attach the weight at one end of the rope
- Throw the weight over the seed-bearing branch.
- Break off the branch by holding the two ends of the rope, and pulling

vii. Climbing trees to collect seed.

- To use this method, you must have skill in climbing trees and using some specialized equipment. This is the method normally used to collect from standing dry zone trees as they are of open form and relatively small. Several methods can be used when collecting seed from standing trees. The roof of a car may serve as a platform.
- Climb into the crown of the tree and use a saw, large knife, or similar implement to cut down seed bearing branches.

6. Seed storage

i. Temperature and relative humidity of the storage environment are two critical factors to pay attention for an environment favourable for seed storage. The moisture content of the seed and the particular crop/ trees are also important factors in seed storage. The lower the temperature and relative humidity, the longer the seeds can be safely stored. Therefore, seeds should not be stored for extended periods in tropical conditions to avoid problems with seed deterioration due to high temperature and relative humidity. Effective seed storage requires the seed to be dried to the prescribed moisture content, a clean well ventilated storage area, if needed treatment of the seed to prevent insect attack, and periodic inspection of the stored seed. Seed should not be stored for extended periods when there is high temperature and relative humidity.

ii. Seed Processing mainly includes the following.

- **Sampling:** To determine the quality of a lot of seed, it must be sampled in such a way so that the samples taken are representative of the entire quantity of seed. The seed quality testing is

performed on part of the representative sample. Therefore, a technically sound sampling methodology is very important so that the seed testing results are valid. Seed sampling and testing are part of the seed procurement process, but it may also be used by emergency staff and local officials to verify the quality of seed before delivery to users or to verify seed quality if the seed has been stored for several months.

- **Testing:** Seed testing provides essential information for determining the quality of a lot of seed concerning such parameters as germination, physical purity, and moisture content. In this way one knows that it meets the technical specification of the order, and that quality seed is being provided to the users. Seed testing should be carried out in a national seed laboratory or laboratories will be established by the provincial forest departments accreted by FSCRD for the purpose.

iii. Quality standards: Seed should comply with quality standards to ensure quality seed is provided to the users. The FAO developed Quality Declared Seed scheme provides seed quality standards that are used as a minimum standard for seed purchased in seed relief activities.

Assessment of seed and seedling supply system for forest plantation in Pakistan

March 2022