Access to high quality germplasm of productive trees for smallholders

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Enabling higher productivity in smallholder agroforestry – not by magic, but by sub-sector assessments

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1. Huge potential gains

In plantation forestry, internal rates of return of 5-10 % from tree domestication are common [1]. But these returns don't benefit tree breeders, unless:

- the breeder is also the farmer;
- they have a profit sharing agreement (communal investment)
- the bred material can be sold at a higher price
- the bred material is provided as a public good paid for by society [2].

Agroforestry species can bring similar results. In Nepal, for example, *Bauhinia purpurea* can offer 2-5 % more fodder per year [3].

Bauhinia variegata (Coiralo) is an important fodder tree in Nepal with an unreleased potential for improvement and use, also in other areas of the world (here in Kenya).

2. Such gains are rarely realised in agroforestry

High quality and yield of agroforestry produce to satisfy market demands require an initial input of adequate germplasm. Such high quality reproductive material is, however, rarely available to small holder farmers and the input supply value chain is therefore often broken (Figure 1) [6].

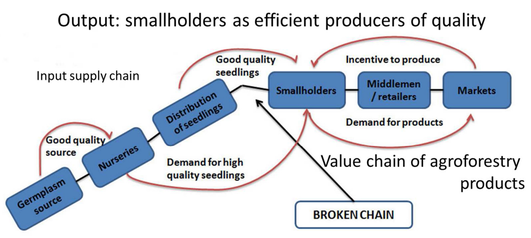

Figure 1. Input supply of germplasm is at the starting point of the product value chain and therefore of crucial importance for the market supply of the end products [4,5,6]

3. Types of seed sources used in agroforestry practise

The source of the material is critical for success. The sources of germplasm available to tree planters can be categorised in five different types (Table 1)[7].

Source type	Brief description
Natural Forest	Natural vegetation, ranging from high forest to woodlands
Farmland	Tree species on farms - planted or remnants of natural vegetation
Plantations	Trees planted in a plantation or woodlot
Seed Orchards	Trees planted in a plantation or woodlot, specifi cally for seed production
Vegetative material	Grafts, stem cuttings, micro cuttings or somatic embryos propagated from selected clones or seedlings. May originate from any of the other source types

Table 1. Types of seed sources available for agroforestry trees [7,13]

In many cases small farmers rely on a supply from farmland seed sources (e.g. in Nepal [8], Tanzania [9], Uganda [10-11], Kenya[12-13], Malawi [14-16], Ethiopia [17-18, 6], Burkina Faso [19-20]), grafted fruit seedlings[21], and plantation crops (e.g. for tea, coffee, cacao etc.).

4. Most sources used are of inferior quality

Many farmland seed sources and a lot of the vegetative material sourced are, however, as illustrated in figure 2 of inferior quality. Access of small producers to markets is therefore severely constrained already by the amount and the quality of their produce [13].

Seed orchards are hardly utilised in agroforestry, because no-one takes responsibility for investment. For vegetative material to be superior, it has to be selected and tested for the purpose and based on a sufficient number of clones to maintain diversity. There are good examples of high yielding vegetative material, e.g. in out grower schemes in India [23] and use of Acacia hybrids in Vietnam [24] as well as problematic cases like un-tested clonal hedges of dipterocarps in Indonesia [25].

It is important to note that the approach to multiplication of fruit trees is different from most other trees. For fruit trees the selection of ideotypes is important (e.g. *Irvingia* and *Dacroyides* in Westafrica [26]). Farmland seed sources are often poor, because collection is made from few un-selected individuals, which may even be related.

5. Leverage points – how can gains be improved?

Leverage of this situation would in principle be easy, by providing small farmers access to material at the high end of the quality scale (Figure 2). In practise, such material is generally reserved for large-scale tree planting because

- the relative costs of producing or buying such material will tend to be higher for the small farmer, or
- the small farmer or the supplier is unaware of (or does not care about) the existence of better material[6].

Leverage points are thus associated to knowledge, production and access related to such reproductive material.

A strong connection between breeding and the benefits of breeding is an advantage as testified by specific examples:

- some outgrower schemes (India),
- one strong agency promoting high yielding clones through a robust network, with a well-set demand for the product (Vietnam), and
- large-scale private companies with control over large planting areas.

An obvious leverage action for smallholders would be breeding as "a global common good", where the market fails to provide, despite the large benefits to society.

Breeding can be carried out at various levels of intensity and by different organisations, depending on the specific species and products. Elaboration of planting zones is a major first step in planning for seed source networks[27].

The identification of the more specific leverage points can be facilitated by a so-called subsector assessment[28]. The purpose of sub-sector assessment is to provide an overview of actors, species, networks, etc. that enables identification of leverage points for improved coordination, consensus on investments, and forward planning for seed sources in landscapes for (i) immediate use and for (ii) future use. Figure 3 below shows input supply chains categorized by source type in a sub-sector assessment[4,6].

	Input supply chains categorised by source type				
Distribution	Mainly controlled by government – under-utilised	Used by NGOs as a cheap way of obtaining seed – overutilised	Mainly controlled by government or large companies - utilised	Mainly controlled by governmen t or large companies – under-utilised	Mainly controlled by Horticulture and NGOs – utilized, un-fortunately also for unknown material
Collection	Genetic potential rarely utilised	Genetic potential rarely considered	Genetic potential variable	Genetic potential good	Genetic potential known for well known cultivars
Sources	Many indigenous species	Limited number of species and most often not optimal source	Mainly industrial species	Limited number of species	Many fruit cultivars
	Natural Forest	Farmland	Plantations	Seed orchards	Veg. Material
	Seed source types				

Figure 3. Subsector assessment of input supply of seed, with sources, collection and distribution as the three levels of organisation and the five seed source categories as the channels [4,13].

As pointed out low quality farmland sources and unselected vegetative material often dominates.

6. The institutional challenge

The institutional challenge is to organise the input supply chain in a way that put high quality reproductive material at the disposal of the small farmer.

The key points are:

- control and financing of seed sources/collection; and
- organisation and financing of distribution networks.

There are different ways of organising input supply.

Each of the 3 functions, sourcing, collection and distribution (Figure 3), can be centralised (C) or decentralised (D).

Seed Supply Model	Example of operational Seed Supply Systems	Institutional setting
Centralised models		
CCC	Centralised government/large NGO system, e.g. many national tree seed programmes	Government model NGO model
CDC	Contract worker or day labourer system, where only collection is outsourced	
DCC	Centralised outgrower system, procurement done by distributor	
DDC	Centralised outgrower system, procurement done by producer	
Decentralised models		
DDD	Farmer to farmer diffusion	Non-commercial model
DDD	Decentralised seed sources, decentralised enterprise model	
CDD	Centralised seed sources, decentralised enterprise model	Commercial model

Table 2. Configurations of the input supply chain and seed supply systems [4,13, 29], cf. Table 1 and Figure 3. In practise four models emerge.

In practice we operate with four major seed system models:

- The government model
- The NGO model
- The decentralised non-commercial model
- The decentralised commercial model

In Table 3, each of these four models (in red) are characterised on different parameters (shown in grey). The models are not only relevant for agroforestry tree seed supply. They are all known and older in crop seed supply also for smallholders [13]. Here we can take advantage of an assessment of their functionality in the equivalent crop seed systems (shown in green).

Input supply chains	Government model	NGO model	Non-commercial decentralised farmer-to-farmer diffusion	Commercial decentralised model
Control of sources	Central government agency	Collection from available tree species on farmland	Farmers	Diverse – central government and private
Diversity of sources	Limited by funding and capacity for protection	Limited to farmland availability or early seeding shrubs	Limited to farmland availability or early seeding shrubs	Limited by funding – disregarded by actors in Tree seed systems
Technical quality	Central government agency	Rarely considered	Rarely considered	Know-how distributed by Central government agencies and NGOs
Supply chain know-how:	Central government agency	With NGO	Not relevant	Know-how distributed by Central government agencies and NGOs
Seed goes to:	NGOs and projects	Other NGOs or free to NGO clients	Other farmers	Decentralised nurseries
Crop seed systems	Considered inefficient	Considered too expensive to scale up	Considered slow and inefficient	Considered the model with the most promise

Table 3. Characterisation of models of seed supply for agroforestry [13].

It is interesting to note that the three models currently used in agroforestry are either inefficient or expensive. There is thus reason to believe that we should look for development of the fourth model to the right in the table.

In particular the CDD configuration, with investment in foundation seed at central level in support of production and distribution at decentral level could be suitable for many trees. Currently it is about the only model which is not promoted in agroforestry[6]. The concept of participatory plant breeding borrowed from crop seed (DDD diffusion), is possibly not ideal for most trees, with indigenous fruits as an exception. The NGO model involving free hand-outs of germplasm of unknown quality tends to undermine the decentralised enterprise models[4].

Utilisation of quality seed sources needs forward planning, coordination, and investments. It cannot in general be handled efficiently by small individual projects, because planning for quality planting material must be done at a landscape level.

7. Recommendation domains, for what areas are we breeding?

This presentation focus on providing access channels for small holders to high quality reproductive material. A prerequisite is that such material exist and can be identified to suit site and purpose of planting. A species consist of several populations, some of which may be adapted to different environments that may be influenced by climate change (Figure 4).

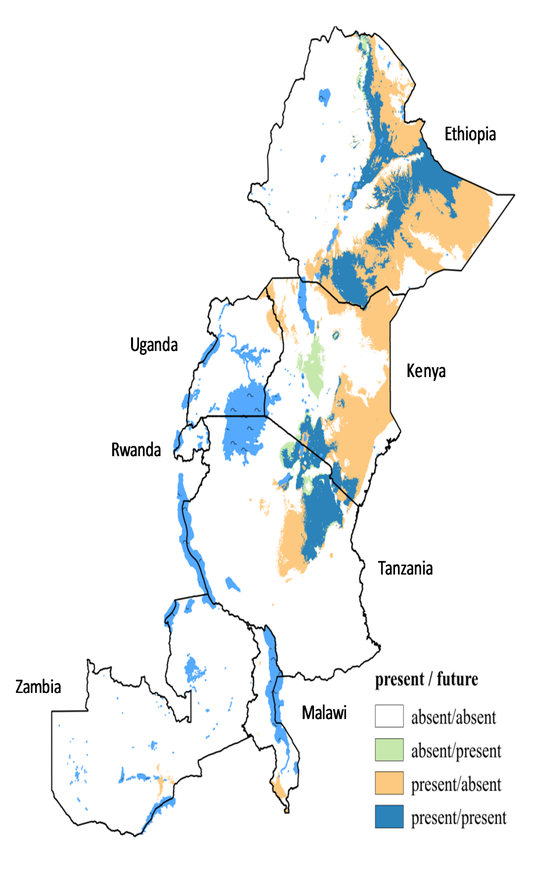

Figure 4. Modelled distribution of faidherbia (Faidherbia albida) under current and future climate in seven countries in Eastern Africa [30, 32]. Distribution and recommendation domains may change as a result of climate change.

Species and seed source recommendation domains are therefore essential as is the development of decision making tools that can guide the individual farmers in their demand for such sources to suit their needs [27,30-32].

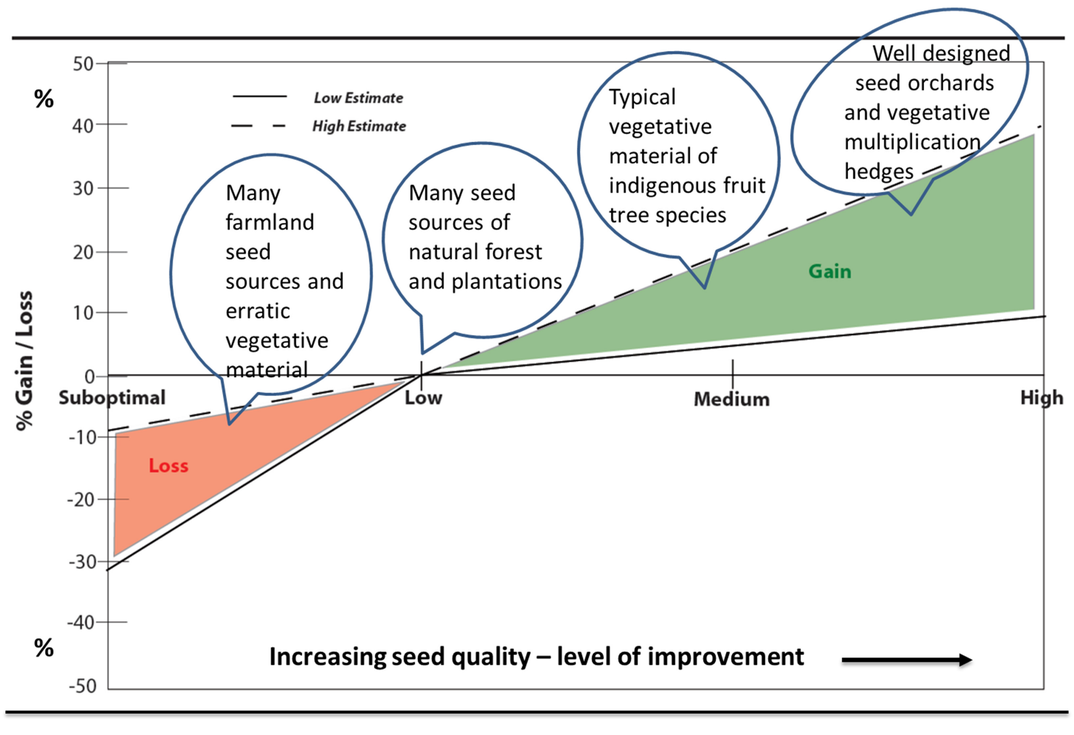

Figure 2. Loss and gain from choice of seed source and genetic improvement [22, 1] .Many sources used in agroforestry are sub-optimal [13, 8-21, 31], with only few examples of medium and high quality sources [23-26] .

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