

Appendix 2

Table A2.1. Summary of the dynamics captured in the causal loop diagrams by thematic section, with key literature used to identify them. Identified system archetypes are shown in bold (Braun, 2002; Table 2).

Thematic sections	Descriptions
Burkina Faso	
1. Centralized seed production (6 feedback loops)	The production and distribution of seeds by the National Tree Seed Centre of Burkina Faso (CNSF) is expensive due to poor road infrastructure. This reduces seed sales and potential clients may refer to other seed sources of poorer quality. Consequently, CNSF tends to focus on a partnership with the Forest Department to increase its share in the national seed market for restoration projects led by the government. In some cases, this has negative effects on the relationship between CNSF and other implementers of restoration projects, who see CNSF taking a sort of monopoly of the seeds market, imposing high seed prices (shifting the burden). However, if a collaboration is established between project implementers and CNSF, this can lead to benefits for both sides and to positive outcomes that are likely to encourage practitioners to seek scientific support from CNSF in future forest landscape restoration (FLR) initiatives and to make use of <u>good quality germplasm</u> (Graudal 1998).
2. Short-term project funding (4 feedback loops)	The dependence on short-term funding for FLR creates disincentives for establishing an effective monitoring system for forest landscape restoration success (growth and underinvestment), leading to a lack of attention to seed quality in FLR efforts. Underfunding also leads to competition between stakeholders involved in FLR for funds (escalation) and a weak consultation of local communities (Bouda et al. 2011).
3. Approach of the Forest Department (4 feedback loops)	Forest officers prioritize focusing their limited resources in enforcing laws that prevent overharvesting over supporting smallholders in seed production and providing silvicultural advice. This results in limited collaboration between smallholders and forest officers and may lead to illegal cutting (shifting the burden). This limited collaboration from forest officers, associated with the administrative burden involved in formalizing the production of nurseries managed by smallholders, discourage official registration of nurseries and makes it difficult to enforce seed collection guidelines (Bassirou 2008, Vallino 2009, Coulibaly-Lingani et al. 2011, Bouda et al. 2011, Tankoano et al. 2015).
4. Fair Benefit Sharing (3 feedback loops)	When illegal logging occurs, lack of trust between smallholders weakens the social capital, which in turn may create competition for remaining forest resources (tragedy of the commons) and favor the monopolization of forest resources by a few individuals in a position of power, undermining the potential for future collective actions (Coulibaly-Lingani et al. 2011, Bouda et al. 2011, Westholm and Arora-Jonsson 2015).
5. Civil society support to tree planters (6 feedback loops)	The civil society often supports local smallholders in planting trees and, when benefits and awareness start materializing, the example is followed by other smallholders. The civil society can also support local seedling producers by providing resources for training. On the other hand, free distribution of seedlings by the civil society to smallholder farmers is likely to undermine market opportunities for local nurseries, unless seedlings are bought from local nurseries (fixes that fail , Raebild et al. 2004).
6. Farmers' nursery networks (4 feedback loops)	When local demand for planting material increases, so does the number of seedling producers. If there is a good degree of cooperation (limits to success), seedling producers can form a network in which they can share information on nursery techniques and location of tree seed sources, supporting each other in meeting seed demand of particular tree species, and improving opportunities to respond to local and regional demands while reducing operating costs.
7. Preferences for exotic species (4 feedback loops)	Cultural taboos and low profitability hinder planting of native tree species, shifting the focus of smallholders towards planting exotic tree species that generate higher incomes (success to successful , Raebild et al. 2004, Etongo et al. 2015).
8. Forest protection or further degradation (5 feedback loops)	In a context characterized by a reduction in forest cover, assisted natural regeneration interventions and regulations on the use of forest resources have been implemented in some areas of Burkina Faso to promote a more effective protection of forest resources and encourage stakeholders' interest in sustainable forest management. In other parts of the country, competition for the remaining forest resources is increasing and soil is degraded, limiting natural regeneration and leading to further environmental damage (tragedy of the commons , Gijsbers et al. 1994, Raebild et al. 2004, Bayala et al. 2011, Savadogo et al. 2012, Schumann et al. 2012, Thiombiano et al. 2013).

9. Conservation of genetic resources (3 feedback loops)	Planting high-quality seeds, adapted to the current and expected future conditions at a planting site, combined with natural regeneration, enhances the chances of tree survival and recovery of the forest ecosystem. The use of good quality seed is important to optimize survival rates and growth performance, increasing the interest of smallholders in using high quality seed and encouraging seedling producers in adopting best practices for seed collection (Broadhurst et al. 2006).
The Philippines	
1. Effectiveness of the Department of Environment and Natural Resources (DENR) (5 feedback loops)	Only a few smallholders producing timber and/or providing forest planting material are officially registered with the Department of Environment and Natural Resources (DENR), which reduces the capacity of DENR to support and cooperate with a broad range of this kind of players in the seed system. This leads to reduced effectiveness of capacity strengthening of smallholders in seed supply, and their ability to produce seedlings for the enhanced National Greening Program (eNGP, growth and underinvestment). The lack of funding available to DENR officers could motivate them to make local communities pay for services that should be free, such as their registration as official timber producers. Such actions can further reduce trust between DENR and local communities. This disconnect between DENR and smallholders feeds a negative loop and disincentivizes producers to register their business with DENR (Gregorio et al. 2004, 2015, Dahal and Capistrano 2006, Germano et al. 2007, Pulhin et al. 2007, Baynes and Gregorio 2008, Catacutan et al. 2008, Harrison et al. 2008, Mercado and Duque-Piñon 2008, Russell et al. 2011, Baynes et al. 2011, 2016)
2. Conservation of the seed sources (3 feedback loops)	The demand for industrial wood is greater than the supply, and pressure increases on the remaining forest resources (tragedy of the commons). Populations of highly valuable trees are reduced to the point that it is difficult to find good quality seed sources. Thus, planting such tree species becomes more expensive and planting material could be of lower quality, making their cultivation less profitable for smallholders (Gregorio et al. 2004, 2011b, Carandang et al. 2006, Bensel 2008, Gravoso et al. 2011, Santos Martín et al. 2012, Le et al. 2014, Peque and Hölscher 2014, Baynes et al. 2016).
3. Private nurseries (3 feedback loops)	Private nurseries generally have the capacity to respond to increases in local demand for trees and seedlings. However, their success may be constrained by the existence of regional public nurseries that compete with them, creating unfavourable market conditions (fixes that fails , Carandang et al. 2006, Mercado and Duque-Piñon 2008, Gregorio et al. 2010).
4. Sustainability of People's Organizations (PO) (5 feedback loops)	The opportunities offered by contracts between DENR and POs — groups of smallholders implementing forest activities defined by DENR — initially attracted many people to join POs. However, over time, the increasingly large size of the POs created a need for strong leadership, without which the long-term operability of POs was put under pressure (limits to success). Moreover, irregular funding and lack of alternative income opportunities drove many PO members to drop out (shifting the burden). As a result, a few remaining powerful members currently dominate the POs, concentrating power and benefits and engaging other smallholders only as workforce (fixes that fail). A diversified access to customers, other than government agencies, to sell seedlings is a way to secure long-term funding and operability of the POs, but this means a good level of cooperation needs to be in place for the POs to function well and adequately respond to demand for seed (success to successful , Catacutan and Mercado 2001, Bertomeu 2002, Dahal and Capistrano 2006, Pulhin et al. 2007, Catacutan et al. 2008, Harrison et al. 2008, Edralin and Mercado 2010, Gregorio et al. 2010, 2011b, Baynes et al. 2015, Gregorio et al. 2017).
5. Predominance of exotic species in tree planting (5 feedback loops)	The main motivation for tree planting is timber production, so smallholders tend to choose fast-growing exotic tree species that have been widely planted in past restoration projects and, hence, have abundant seed sources and available silvicultural knowledge (success to the successful). By contrast, native tree species have largely been neglected by research efforts. Furthermore, the reproductive biology of some native tree species (e.g. masting) constrains seed collection and leads to increased use of wildlings, which often perform poorly when transplanted, due to damage to the root system during collection (Emtage and Suh 2004, Gregorio et al. 2004, 2011a, 2012, Carandang et al. 2006, Bernaldez and Mangaoang 2008, Santos Martín et al. 2012, Schneider et al. 2014, Nguyen et al. 2014).
6. Regional nurseries (3 feedback loops)	Central nurseries have been established to address the need for high-quality planting material. However, high costs, seedling mortality related to transportation, and the availability of tree seed for a very limited range of tree species, makes this centralized model inefficient in responding to the demands of smallholders (fixes that fails , Gregorio et al. 2008, 2011b, Kadda et al. 2008, Mercado et al. 2010).
7. Mismatch of funding and goals (6 feedback loops)	Ambitious reforestation plans are being implemented in the Philippines to counter deforestation and forest degradation. However, the ambitious goals are not supported by adequate funding on a per hectare basis; thus, regulations on seed quality are difficult to implement effectively (growth and underinvestment). Furthermore, monitoring systems tend to focus on short-term indicators and encourage fraudulent reporting, because funds are only released when an 85% survival rate is reached. Limited success reinforces the tendency for central control, exacerbating miscommunication with the local government units (fixes that fail). This leads to a lack of consultation with local communities, delays in funding and inappropriate approaches to strengthen local capacities and institutions (growths and underinvestment , Catacutan and Mercado 2001, Pulhin et al. 2007, Gregorio et al. 2008, 2011b, 2017).
8. Local knowledge transfer (3 feedback loops)	Appropriate training of local communities enables them to acquire more experience in seed production. Once confident enough, community members can share their knowledge with other people in their villages. This acquisition of knowledge leads to a greater degree of trust between DENR and local communities, and a greater degree of freedom in the

	design of forest restoration initiatives (Bertomeu 2002, Emtage and Suh 2004, Bernaldez and Mangaoang 2008, Harrison et al. 2008, Mercado and Duque-Piñon 2008, Baynes et al. 2011, Gravoso et al. 2011).
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