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RESEARCH PAPER

Decentralization of Tree Seedling Supply Systems for Afforestation in the West of Yunnan Province, China

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Abstract At present, China has the highest afforestation rate of any country or region in the world, with 47,000 km^2 of tree plantations undertaken in 2008. While the prominent role of the central government's afforestation programs is well-known, little is understood of how the system of tree seedling production and distribution supports afforestation efforts. More importantly, little attention is paid to how small-scale farmers access high quality tree germplasm in the afforestation programs. This paper examines the seedling supply system in the west of Yunnan Province in China by focusing on the three types of tree nurseries (state, collective and individual) that are being operated for the development of smallholder forestry especially in the context of decentralization. The research reveals that forestry decentralization has provided support for smallholder access to high quality planting materials and improved the effectiveness of nursery management. The reform has enabled the engagement of various forms of nurseries and created a hybrid system of state nursery operations. However, the state monopoly over the major seedling supply system using its inherent technical, market, policy and institutional

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advantages has limited the development of small-scale nurseries. The policy implication of this research is that improvements to the governance structure in the supply system of tree seedling may require more investment in nursery techniques, market information and provision of incentives to enhance small-scale nurseries and to contribute to seedling production.

Keywords Smallholder forest-dependants · Forest tenure reform · Sloping land conversion · Tree germplasm · Nursery certification

Introduction

China is one of the few developing countries that have enjoyed a great forest transition with the historical path from net deforestation to net forestation (Rudel et al. 2005; Mather 2007; Xu et al. 2007), where the forest coverage has increased from about 8.6% in 1950 to 20.4% at present (SFA 2010). This impressive forest recovery has been due not only to the improved implementation and enforcement of forest protection policy and laws, but more importantly to the vast afforestation program in which the central government has invested since 1980s (Rozelle et al. 2000; Li 2004; Chokkalingam et al. 2006). FAO (2007) reported that China's forest plantation area reached 4 M ha annually from 2000 to 2005. More recently, the Chinese government has begun implementing the world's largest and highest-funded afforestation program to convert marginal agricultural land into forest, known as 'Sloping Land Conversion Program' or 'Grain for Green', involving millions of mountain-dwelling communities (Zhang et al. 2000; Xu et al. 2004). Plantation forestry accounted for about 31.8% of total forest area in 2008 and is considered the highest total area globally (SFA 2010). The crucial challenge for the various large-scale afforestation projects is to ensure that a large quantity of high quality planting materials each year reaches and is suitable for the diverse geophysical conditions, particularly given the context that most project beneficiaries are small-scale farmers living in remote regions with geographical and technical constraints.

Apart from the forest transition, Chinese society is undergoing a socioeconomic transition. Rapid economic growth has supported millions of people to overcome poverty (Ho et al. 2004), while the political and administrative reforms characterized as decentralization have provided opportunities to lower level administrative bodies to exercise greater say in decision-making (Oi 1999). These socioeconomic transformations have had a profound impact on the country's forest management (Hyde et al. 2003; Xu and Ribot 2004). Decentralization in the forestry-related sectors has taken many forms including forest reallocation, market mechanisms that lead to downsizing state administrative bodies, and community participation in decision-making. In term of afforestation efforts, the decentralization reforms have opened up more flexibility in forest operations—for example in the seedling production system—in contrast to the 'centralized command' during Chairman Mao's period.

Existing literature supports the theory that decentralized production of forest seedlings provides the highest effectiveness for supplying planting materials to

smallholders (e.g. Böhringer et al. 2003; Gregorio et al. 2008; Harrison et al. 2008). However, what is realistic and practical in terms of a decentralized system for developing countries is still not well understood. Experiences from the Southeast Asia region have informed that the key form of decentralized seedling production system (community nurseries) exhibits a wide range of sustainability problems such as periodic variation in project-orientation, over-reliance on external support, low production capacity, and barriers in technology transfer (e.g. Gunasena and Roshetko 2000; Gregorio et al. 2004; Mercado and Duque-Piñon 2008; Roshetko et al. 2010). Further, in-depth understanding of the various experiences including community nurseries in the decentralization of seedling production in developing countries could prove useful. In the current literature, there is a poor understanding of China's tree seedling supply system, especially the access by small-scale farmers to high quality germplasm.

This study examined the seedling production and supply system in West Yunnan Province, China, by focusing on the three types of tree nurseries—state, collective and individual—and their operations in the development of smallholder forestry, especially within the context of decentralization. The research was designed to provide in-depth insights into how the decentralized tree seedling supply system supports the afforestation program and local needs in the west of Yunnan Province.

The remainder of the paper is set out as follows. The study site is described, then the research method is outlined. A historical overview of nursery development in the west of Yunnan is presented. The recent decentralized seedling supply system is described, with a focus on various nursery types, their production and operations and the overall seedling supply chain. Finally, key findings and policy implications are reported.

The Study Site

The research site is Baoshan municipality in Western Yunnan, China (98°05′–110°02′N, 24°08′–25°51′S) bordering with Burma, and situated on the upper watershed area of the Yangtze, Mekong and Salween Rivers. Administratively, the municipality comprises five counties (Longyang, Tengchong, Longling, Shidian and Changning) (see Fig. 1). Baoshan is located in a typical subtropical zone with evaluation ranging from 535 to 3,780 masl and rainfall 700–1,200 mm with annual temperature of about 14°–17°. The territory of Baoshan covers 19,637 km^2, of which 92% is mountainous, containing 1.15 M ha of forestland of which 81.3% is collectively managed. Forest cover in Baoshan is 61.9% dominated by Pine (*Pinus yunnanensis*, *Pinus armandii*, *Pinus kesiya*), alder (*Alnus spp.*) and fir (*Taiwania flousiana*), mostly planted in last two decades, after the rapid deforestation during the period of the Great Leap Forward and the Cultural Revolution. Fruit trees including walnut, chestnut, plum and persimmon are being planted for agroforestry functions and upland economic development. Table 1 summarizes the biophysical characteristics and socio-cultural features among the various counties of Baoshan Municipality.

Fig. 1 Location of study site

With total population of 2.41 M, there are 14 distinct ethnic groups in the municipality, the largest including Thai, Yi, Lisu, Bai, Jingpo and Bulang, all of which have been resident in Baoshan for centuries. The ethnic communities previously practiced upland agriculture mainly for subsistence needs but their farming systems are now more integrated into the market economy. At present, farmers are actively involved in afforestation activities due in particular to: (1) increasing value of timber and non-timber forest products; (2) state investment and subsidises for afforestation (including under the Sloping Land Conversion Program); and (3) forest tenure reform to allocate collective forestland to individual household as an incentive. This also has increased the demand for tree seedlings to meet the diverse needs of small-scale farmers.

Located on the margins of China, Baoshan is also classified as one of China's most undeveloped regions. The steep mountains and geophysical conditions place limits on farmers wanting to access technology, market opportunities and central funding support as well as access to other resources for improving their livelihood. Current market integration and forest policy reforms have provided more rights to forest dependents for decision-making. However, questions remain about how those marginalized groups can gain greater benefits from the Ecological Construction Program (the main state program for afforestation) because this would depend not only on program operations and investment, but more importantly on farmers' access to high quality planting materials. How marginalized groups can gain from

Table 1 Biophysical characteristics and socio-cultural features of the study area

Study site	Longyang county	Tengchong county	Longling county	Shidian county	Changning county
Area (km^2)	4,833.2	5,696.9	2,796.4	1,937.2	3,790.4
Elevation (m)	627–3,650	964–3,779	536–3,202	517–2,871	597–2,870
Annual rainfall (mm)	1,037.3	1,428.5	2,038.8	1,038.1	1,242.7
Ethnicity	Han-Chinese, Yi, Bai, Thai, Lisu, Miao	Han-Chinese, Thai, Lisu, Hui, Bai, Wa, Jingpo	Han-Chinese, Lisu, Yi, Thai, Achan	Han-Chinese, Yi, Bulang, Wa, Hui, Lisu	Han-Chinese, Yi, Thai, Miao, Bulang
Total population (1000, in 2008)	887	633	275	325	344
Net income of farmers per capita (USD, in 2008)	450	440	368	351	399
Dominant forest vegetation	Pine (*Pinus yunnanensis*, *Pinus armandii*), Eucalyptus, alder (*Alnus spp.*) walnut	Pine (*Pinus yunnanensis*, *Pinus armandii*), fir (*Taiwania flousiana*, *Tsuga dumosa*), beech, oak	Pine (*Pinus yunnanensis*, *Pinus kesiya*), fir (*Taiwania flousiana*) alder (*Alnus spp.*)	Pine (*Pinus yunnanensis*, *Pinus armandii*), alder (*Alnus spp.*)	Pine (*Pinus yunnanensis*, *Pinus kesiya*), alder (*Alnus spp.*)
Total forest area (ha)	237,540.0	383,455.3	170,337.4	104,700.4	198,771.4
Natural forest area (ha,%)	150,487.4 (63.36)	288,374.8 (75.20)	133,110.2 (78.15)	26,773.7 (25.57)	136,746.3 (68.80)
Plantation forest area (ha,%)	87,052.6 (36.64)	95,080.5 (24.80)	372,27.2 (21.85)	77,926.7 (74.43)	62,025.1 (31.20)

Source Yunnan Statistical Yearbook (2009), Baoshan Forestry Bureau (2010)

the program is also the central question of this study to assess the effectiveness of the decentralized tree seedling supply system.

Research Method

Data were collected through a survey in all the five counties of Baoshan Municipality, as well as interviews of informants and focus group discussions, carried out in 2010. Survey respondents included operators at state nurseries ($n = 5$), individual and collective nursery owners ($n = 20$), and nursery staff ($n = 60$). The area is one of the global benchmarking research sites of the World Agroforestry Centre (ICRAF) in China, and an additional 50 respondents were randomly selected from the smallholders of the six villages in which ICRAF has been engaged in long-term research. Additionally, interviews were conducted with forestry officials from the Yunnan provincial forestry department ($n = 4$) and from the forestry bureau of each county in Baoshan ($n = 18$) to understand the system of access and distribution of tree seeds and seedling and nurseries operations as well as history of nurseries development in Baoshan. During the fieldwork interactions with respondents, semi-structured interviews were adopted to obtain greater insights into how the supply system was operated and into people's experiences and perspectives. A total of eight focus group discussions with forestry officials and nursery operators were conducted to analyze current problems and opportunities for improving the seedling supply system. Secondary data were also collected about nursery history and development, and government policy and programs.

Descriptive statistics including frequencies, percentages and means are used to present the dynamics of forestry and nursery size, operation, species and economic status. Descriptive information is presented qualitatively, especially to provide an in-depth picture of how the various stakeholders are involved in the nursery system, institutional arrangements and the seedling governance structure.

Seedling Supply System Development: A Historical Overview

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. Table 2 outlines the historical progress of nursery development in Baoshan, and Fig. 2 describes the changes in nursery number, area and production from 1978 to 2009. 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.

Table 2 Historical path of nursery development in Baoshan

Period of time	Political and social context	Characteristics of nursery operation
Before 1949	World War II Civil War	A few nurseries funded by government (less than 10), nurseries abandoned during the war
Early 50s to mid 60s	Building state forest farm Collectivization 'Great Leap Forward'	State-owned and collective-owned nursery operated under the central-planning model Producing seedling for state forest farms Seeds were purchased from Bureau of Grains *Pinus* spp. are the major species for afforestation
Mid-60s to late 70s	Cultural revolution.	The development and operation of nurseries was halted
Late 70s to mid-80s	Reform and opening market policy Decollectivization Deregulations	Increase in the number of individual nurseries; government cuts the budget for state nurseries Quantity-oriented production to meet increasing afforestation activities A diversity of species was selected without much concern about species-site matching and ecosystem suitability Focus on timber stocking and fast-growing species
Mid 80s to late 90s	Increasing international cooperation Increasing government investment	Government support for development of seeds base, and grafting stock for state nurseries Nurseries focus on exotic species (*Eucalyptus* spp.) with support by international investment and donor such as the World Bank Government started to retake control of state nurseries
Late 90s to the present	Natural forest protection program (logging ban) Sloping land conversion program (Grain for Green) Launching tree seeds laws in 2000 Introduction of nursery certification in 2001	Deregulation of state nurseries Improved quality control by nurseries operators and government monitoring system State, collective and individual nurseries for meeting the large demands from state afforestation program Nurseries can produce diverse species for market (fruit trees, indigenous species, timber species as well as exotic species)

From the late 1970s, after the collapse of collectivization and the *centralized-command* system, the Chinese government opened its markets and reformed the political administrative system in order to solve food shortages and promote economic development. The reform started by not only decentralizing the financial burdens to local bodies, but more importantly transferring decision-making powers to lower administrative levels. The decentralization reform enabled increasing engagement of the private sector in tree seedling production. Development of the nursery sector also benefited from several afforestation programs that were launched by the state to respond to past deforestation. In 1981, a new policy has passed by the State Forestry Administration (formerly Ministry of Forestry) enabled private individuals to contract the operation of state nurseries that provided more flexibility to state nurseries for self-planning, seedling production and marketing. In parallel,

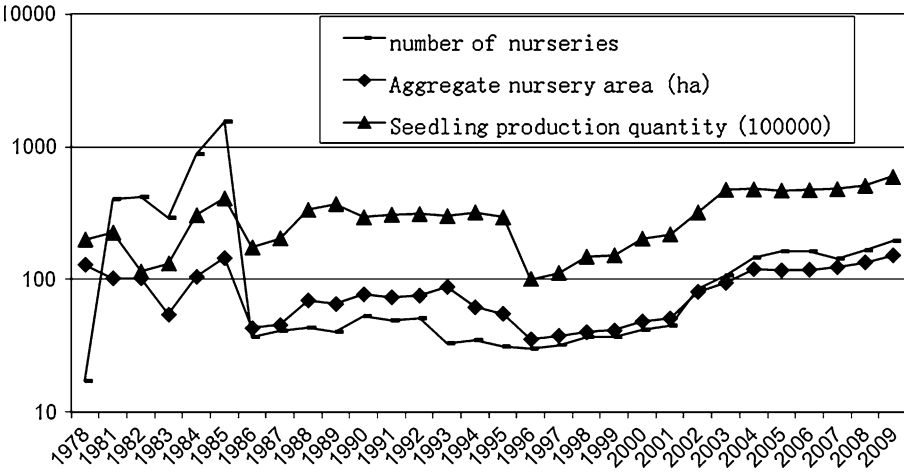

Fig. 2 Changes of nursery number, area and production in Baoshan municipality, 1978–2009

the forest tenure reform to redistribute forestland to individual households proved a major incentive for small-scale farmers to establish tree plantations.

Rapid growth in the number of nurseries did not automatically lead to a dramatic increase in production capacity due to technology constraints, poor infrastructure and lack of experience. From 1978 to 1982, the number of nurseries increased from 17 to 421, and reached 1,558 in 1985 (Fig. 2). Although the production areas also increased, the seedling production capacity did not expand correspondingly. Moreover, all nurseries operated for the quantity-oriented production without consideration of site-species matching that affected the success of afforestation. As a result, a great number of collective and individual nurseries were unable to compete in the market and eventually went bankrupt. After this, the state took back control of state nurseries by providing subsidies to ensure the government afforestation programs could meet their needs for seedlings. Figure 2 shows the dramatic drop in terms of number of nurseries and seedling production area in 1986 after several years of rapid growth.

Since the late of 1980s, nursery development has stabilised as the state, collective and individual nurseries become the three key forms. State nurseries continue to play a key role in seedling production to meet the massive needs of the state afforestation program. Notably, there was a rapid rise in the number of nurseries, seedling production area and number of seedlings produced from 1998, as the national Sloping Land Conversion Program and the Natural Forestry Protection Program was assigned billions of hectares of afforestation targets each year. In order to ensure high quality seedlings for those state afforestation programs, the State Forestry Administration launched the *Tree Seeds and Seedlings Law* and introduced the nursery certification schemes in 2000 and 2001 respectively.

Along with decentralization, the choice of tree species for nurseries also changed. During the centralized period, given the market and technology constraints, the

species raised in the state and collective nurseries were mainly those selected for timber and which were relatively easy to produce with locally available seeds, including *Pinus* spp. (*P. Kesiya*, *P. yunnanensis*, *P. armandi*), *Alnus nepalensis* and *Taiwania flousiana Gaussen*. The major mission of these nurseries was to meet the needs of the state program that was mainly driven by high quantity rather than quality. Along with the decentralization reforms, the policy of Reform and Opening Market provided more options for exotic species including *Eucalypts spp*. while fast growth became a key factor for species selection especially as the state wished to rehabilitate the landscape into *green* areas following serious deforestation. The introduction of exotic species was also associated with the evolution of technologies including the seedling pot introduced by World Bank funded projects for eucalypts production. This program led to major improvements in seedling survival rates and quality as well as increasing the production capacity of nurseries. The mission of nurseries was however to produce a large quantity of tree seedlings. Nowadays, the nurseries are raising a wide range of species that meet both ecological and economic functions, as well as the needs of markets and of government programs. The nurseries, particularly the state-owned ones, also changed their key functions from seedling producers to multi-purposes resource centres.

Nursery Types and Scales After Decentralization Reform

The majority of forest nurseries in Baoshan municipality are State-owned, collective-owned or individually owned. Nurseries of each type are required to obtain certification from the forest department for seedling production and trading. The scale of each nursery is determined not only by their physical condition and technological capacity, but also their close links with the clients and in particular the government. In addition to the main three nursery types, there are project-based nurseries supported by international cooperation projects and uncertified farmer nurseries which operate at the community level for improving local accessibility of planting materials as well as for the needs of specific development projects. Because these other nursery types are temporary and not officially certified for seedling production, they are not the focus of this study.

The Characteristics of State Nurseries

The state nurseries serve as the central nursery in each county and play a major role in providing seedlings supporting the afforestation programs at the national, provincial and prefectural levels as well as for forest restoration in national parks. State nurseries are administratively registered in the forest department at prefectural level where they are also certified for production and trade. The geographical concentration of state nurseries is in suburban areas on government-owned land. Nursery sizes typically range from 1 to 5 ha (average 1.6 ha), and can produce on average 800,000 seedlings annually. The state nurseries thus have easy road access and infrastructure investment by the state, but they are located far from the upland

Table 3 Numbers, sizes, and production levels of state nurseries in Baoshan municipality, 2004–2009

Study site	Longyang county	Tengchong county	Longling county	Shidian county	Changning county	Total
2004						
Number of nurseries	2	12	1	1	9	25
Production area (ha)	13.33	8.67	3.53	11.27	10.00	46.80
Seedling production (1,000)	9,000	8,500	1,300	2,200	2,220	23,220
2005						
Number of nurseries	2	12	1	1	9	25
Production area (ha)	12.60	8.33	2.00	11.93	7.33	42.20
Seedling production (1,000)	7,000	6,790	1,500	2,350	34,500	2,10,900
2006						
Number of nurseries	2	12	1	1	9	25
Production area (ha)	12.60	8.33	2.00	11.40	8.40	42.73
Seedling production (1,000)	6,980	8,330	1,100	2,200	3,450	22,060
2007						
Number of nurseries	2	12	1	1	9	25
Production area (ha)	12.33	7.53	2.00	10.80	9.00	41.67
Seedling production (1,000)	6,680	7460	1,000	1,900	3,510	20,550
2008						
Number of nurseries	4	13	1	1	10	29
Production area (ha)	15.93	9.33	2.27	12.07	9.33	48.93
Seedling production (1,000)	7,080	8,330	1,200	2,400	3,552	22,562
2009						
Number of nurseries	3	14	1	1	16	35
Production area (ha)	15.20	9.13	0.87	6.85	9.93	41.98
Seedling production (1,000)	4,050	10,299	1,420	2,276	3,468	21,513

communities and afforestation sites. The number of state nurseries in each county depends on the allocation of the county's land available for plantations and the afforestation program. As indicated in Table 3, Longyang and Tengchong have a comparatively larger-scale state nursery operation in terms of nursery number, aggregate area and quantity of seedling produced.

State nurseries also function as training centres which provide the technology support for other nursery operators or farmers covering a wide range of activities, including seed collection, seed treatment, propagation and grafting. Trainings is organized by the government in association with particular afforestation programs, including the Sloping Land Conversion Programme. State nurseries are also research and resource centres for the purpose of evaluating and introducing new species, selecting the best local varieties and providing high quality propagating and grafting stock and inoculum.

The management of state nurseries is presently more decentralized because it allows individuals to enter into contracts with the government (forest department), with some of the profit going to the government as a leasing fee and the rest retained by the managers. Although the ownership belongs to the state, nurseries operators have full decision-making power including species selection, financial management and staff recruitment. This institutional arrangement aims to provide greater incentive for nursery operators for production, while allowing the government to play its role in monitoring and inspection. It is also a key form of decentralization reform for state nurseries to separate between operation for seeding production and administrative functions.

Characteristics of Collective Nurseries

Collective nurseries exist in three forms: collectively owned by villagers or communities for producing seedling for the communities and market; jointly owned by the shareholders—i.e. several individuals—for commercial seedling production; and collectively owned as Township Forest Stations to produce seedling for the market. All are registered by division of seed and seedling at forest department at the county level, and there are no major differences between the three forms of collective nurseries. Collective nurseries are usually located closer to communities or in townships where farmers have easy access. Nursery size and market links are highly variable. Areas range from 0.5 to 3 ha (average 0.82 ha), and annual production capacity averages 566,000 seedlings (Table 4). A number of collective nurseries have evolved into township and village enterprises (TVEs) for commercial seedling production.

Demand of seedling and market competition are the key factors that influence the development of collective nurseries so not all counties have collective nurseries. Longling and Shidian are relatively small counties and are located near the large seedling production region of Longyang and Tengchong, so neither has an officially registered collective nursery. As with state nurseries, collective nurseries are permanent, and require sound infrastructure to ensure production capacity and high seedling quality to withstand competition.

Table 4 Numbers, sizes, and production levels of collective nurseries in Baoshan municipality, 2004–2009

Study site	Longyang county	Tengchong county	Changning county	Total
2004				
Number of nurseries	2	8	2	12
Production area (ha)	1.33	7.40	1.33	10.07
Seedling production (1,000)	600	5970	350	6,920
2005				
Number of nurseries	2	9	2	13
Production area (ha)	1.00	8.13	1.20	10.33
Seedling production (1,000)	440	5,560	180	6,180
2006				
Number of nurseries	2	9	2	13
Production area (ha)	1.00	9.13	0.93	11.07
Seedling production (1,000)	390	5,590	200	6,180
2007				
Number of nurseries	2	9	2	13
Area covered (ha)	1.20	8.33	2.03	11.57
Seedling production (1,000)	350	5,970	300	6,620
2008				
Number of nurseries	2	10	2	14
Production area (ha)	1.20	9.33	1.03	11.57
Seedling production (1,000)	430	6,390	160	6,980
2009				
Number of nurseries	2	10	3	15
Production area (ha)	1.20	8.00	1.46	10.66
Seedling production (1,000)	200	11,280	945	12,425

There are no collective nurseries in Longling and Shidain counties

Characteristics of Individual Nurseries

Individual nurseries are relatively small and are operated by individual farmers to meet their own or their community's needs as well as for commercial purposes. Individual nurseries are located in countryside close to the afforestation sites and upland communities. Although most are permanent, they lack investment in infrastructure. The operators rent the land from villagers or use their own plots for seedling production. The typical size is 0.6 ha with annual production of 170,000 seedlings (Table 5). Officially, they are registered with the forest department, which monitors their production and trading.

Individual nurseries are highly flexible and responsive to market changes. Production quantities of the individual nurseries change over the time in response to the afforestation programs, particularly in Longling County. As a major afforestation region, Longyang and Tengchong have the most active individual nurseries, while there is no individual nursery in Shidian due to scarcity of land.

Table 5 Numbers, sizes, and production levels of individual nurseries in Baoshan municipality, 2004–2009

Study site	Longyang county	Tengchong county	Longling county	Changning county	Total
2004					
Number of nurseries	34	58	12	6	110
Production area (ha)	26.67	24.47	8.93	2.67	62.73
Seedling production (1,000)	5,940	9,230	2,330	450	17,950
2005					
Number of nurseries	34	69	14	7	124
Production area (ha)	24.53	26.00	10.47	3.60	64.60
Seedling production (1,000)	6,800	9,890	2,370	770	19,830
2006					
Number of nurseries	34	69	14	7	124
Production area (ha)	24.53	25.80	10.47	3.80	64.60
Seedling production (1,000)	6,730	9,580	2,350	540	19,200
2007					
Number of nurseries	36	55	9	5	105
Production area (ha)	26.80	28.07	11.27	4.20	70.33
Seedling production (1,000)	7,210	10,850	2,250	750	21,060
2008					
Number of nurseries	33	73	11	5	122
Production area (ha)	25.80	31.33	12.43	4.30	73.86
Seedling production (1,000)	6,990	11,280	2,560	870	21,700
2009					
Number of nurseries	30	79	30	5	144
Production area (ha)	12.80	31.24	51.43	3.70	99.17
Seedling production (1,000)	3,600	10,695	5,900	4,863	25,058

There is no individual nursery in Shidian county

Decentralized Nursery Production and Operation

After the decentralization of nursery management, 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.

The three nursery types share many of the same species, but in different relative quantities. The species are grouped as ecological trees and economic species. The former are used for establishing forest stands (mostly the timber species) for the purpose of maintaining and improving the ecological functions and services including biodiversity conservation and reduction in soil erosion. The latter species are planted for non-wood products including fruit, edible oils, nuts, fodder and industrial materials (e.g. rubber) for providing cash income. Recently, exotic or non-native tree species have raised concern because of their potential for being biologically invasive and adversely affecting habitats and bioregions. Table 6 lists the key tree species commonly raised in the nurseries of Baoshan municipality. In state nurseries, a high proportion of the seedlings of ecological species is used for the government afforestation programs, while collective and individual nurseries focus on economic species. A current shift in species requirement for state program of tree plantations has increased the need for economic tree species (particularly walnut), because Yunnan provincial government would like to promote a win–win approach for conservation and development in poor mountainous regions. To obtain superior or elite varieties, state nurseries built their own resource base for mother tree management. This however requires a large financial investment and technological capacity that is not affordable to collective and individual nurseries. As a result, those nurseries have to tie up with the state nurseries to ensure production of superior varieties and high seedling quality.

The three types of nurseries operate differently in response to the increased needs of government tree planting programs and market sales. Production of tree seedlings for state afforestation projects by nurseries is more contract-based, while the nurseries bid for a planned quantity of certain species. A contract is usually set up between the government and the nurseries, with the Seeds and Seedling Stations of

Table 6 Tree species commonly raised the nurseries of Baoshan municipality

Species group	Common name	Scientific name
Ecological trees	Pine	*Pinus* spp. (P. *Kesiya*, *P. yunnanensis*, *P. armandi*)
	Yunnan Yew	*Taxus yunnanensis*
	Alders	*Alnus nepalensis*
	Flous Taiwania	*Taiwania flousiana Gaussen*
	Chinese fir	*Cunninghamia lanceolata Hook*
Economic trees	Oil tea (red flower)	*Camellia Chekiang-oleosa*
	Tsao-ko Amomum	*Amomum tsao-ko Crevost et Lemaire*
	Persimmon	*Diospyros kaki Thunb.*
	Jatrophe	*Jatrophe curcas*
	Walnut	*Juglans sigillata Dode*
	Chestnut	*Castanea mollissima Blume*
	Tea	*Camellia sinensis O.Kunrze*
	Luculia	*Luculia pinceana Hook.f.*
Exotic trees species	Oil tea (white flower)	*Camellia oleifera Abel*
	Maiden eucalyptus	*Eucalyptus maideni F.V.Muell.*

the forest department at county level taking responsibility for monitoring the implementation of the contract. Although the state nurseries are sufficiently competitive to win large contracts, typically they cannot produce an adequate quantity of seedlings and have to contract with several non-certified small-scale seedling producers (SSSP) or certified collective or individual nurseries to jointly fill the contract. Thus, state nurseries are obligated to not only produce seedlings in the required quantity and quality, but also to ensure high seedling quality from their sub-contracted nurseries. State nurseries also produce for the market, where some buyers come from other prefectures and counties. Collective nurseries and individual nurseries are either contracted with the state nursery or operate on their own depending on the market demands; occasionally they bid to supply seedlings for large state afforestation projects.

The Decentralized Seedling Supply System

Several actors are involved in the tree seedling supply system for small-scale forestry development, with two types of supply chains existing (Fig. 3). In the *free market model* the three types of nurseries sell the seedling directly to famers in the market. Farmers tend to buy from nurseries located near their land that provide high quality seedlings at a low price. However, this is not a mainstreaming of seedling supplying, because the massive government investment in tree plantations consumes most of the seedlings being produced. The *state-driven seedling supply system* has a more complicated supply chain. In general, the forestry department will call bids for seedling production based on the government afforestation targets. Mostly, the state nurseries will win the bid, and will subsequently contract individual or collective nurseries as well as non-certified small-scale producers to produce the required amount of seedlings. The individual or collective nurseries may also further sub-contract to the non-certified nurseries for seedling production. Once the seedlings are produced and their quality verified, these are transported to the township forest station that then takes the responsibility to distribute them to administrative villages according to forest department plans. Finally, the administrative villages allocate the seedlings to natural villages and eventually the seedlings reach the individual households.

Within the seedling flow in the state-driven model, there are three forestry department's stations that play a leading role in monitoring and evaluation: (1) the Seed and Seedling Station is responsible to check the quality of seedling, (2) the Pest Inspection Station ensures the seedling are pest free, and (3) the Forest Resource Station takes overall responsibility for monitoring and evaluating plantation performance. Each batch of seedling will be marked by producers for subsequent tracking. After approvals are obtained from the forestry stations, the state nurseries can claim reimbursement from the forest department for the cost for seedling production, and then refund the contracted nurseries. This supply system is aimed at ensuring high quality of planting materials and ultimately success of the state afforestation program.

Nursery certification schemes play a critical role in maintaining seedling quality. Nurseries are in general required to hold two certificates. The *Certificate for*

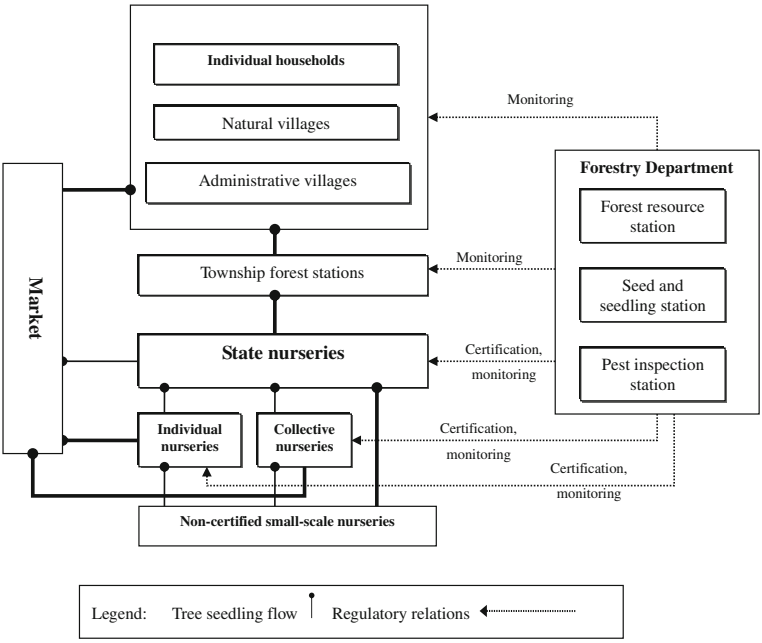

Fig. 3 Relations of actors in tree seedling supply system

Production requires the nursery to meet some basic requirements including land-use approval, seeds source approval, pest inspection approval of nursery, as well as the approval of 100,000 RMB (about 15,000 USD) as a start-up budget for registration. If the production area of the nursery is less than 3.3 ha, the nursery is also required to recruit approved trained technicians. Once a nursery meets those requirements and obtains certification of production, they can apply for the second certificate (the *Certificate for Trade*), for which there is no special qualification requirement. The nursery operator is then required to trade according to the *Seeds and Seedling Law*, including provisions for seedling labelling. The two certificates must be renewed every two years, at which time the forest department checks the performance of the nurseries. Any nursery producing seedlings for government or market without these certificates is regarded as illegal. An exemption for certification is allowed where seedling are for self-use only, i.e. non-commercial production.

The certification schemes in the tree seedling supply system ensure seedlings quality by enhancing the role of government in monitoring and verification of production and trade. However, the certification schemes also pose institutional barriers for small-scale seedling producers who have difficulty entering the tree seedling supply system. As a result, practically all non-certified small-scale seedling producers have to connect with large producer and act as satellite nurseries by jointly using the certificates of the large producers. This limits the development of small-scale nurseries and subsequently impedes its effectiveness.

Discussion

It is widely acknowledged that decentralization reform will improve the effectiveness and efficiency of government administration (Rondinelli et al. 1989), delivery of public service (Rondinelli and Nellis 1986) and natural resource management (Ribot and Larson 2005). While a great deal of attention has been given to the differences in the overall forms of decentralization, understanding remains limited of the variations in decentralization processes and outcomes, particularly in the forestry sector's seedling production system. Drawing from empirical data, this paper highlights how 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, it is also argued that 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. To elaborate the research findings and its policy implication, this section discussed how to further improve the decentralization reform in tree seedling system in three aspects: (1) production and operation, (2) nursery research, and (3) seedling marketing.

It is clear that decentralization reform in forestry 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 over-reliance on state subsidies, low seedling quality and low nursery profitability (Carandang et al. 2006; Harrison et al. 2008). With the diversification of the nursery types, it is clear that 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 still 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.

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.

At present, nursery research including introduction of new species, new technology and species domestication in China is highly concentrated in state nurseries, as the government program and investment are the main sources for supporting research. This state-led research scheme inevitably leads to poor extension services, less attention to indigenous species and difficulties in meeting local diverse needs of seedlings (Böhringer and Ayuk 2003). The key is to promote farmer-led nursery research for maximizing the use of local knowledge and resource mobilization to promote technology extension, local empowerment as well as selection and domestication of endemic, endangered and economically valuable species. In practice, participatory methods including Participatory Tree Domestication (Simons and Leakey 2004) and Participatory Technology Development (He et al. 2009) have been applied extensively for strengthening farmer-nursery research. These techniques are a cost-effective way to develop locally feasible and environmentally friendly technology for the development of agroforestry species that will consequently contribute to local income generation and biodiversity conservation (He et al. 2009, 2011). Mainstreaming of the participatory approach in nursery research is required, which can be achieved through both government and NGOs providing support for community-based farmer nurseries (Carandang et al. 2006; Roshetko et al. 2010).

For promoting further decentralization in the seedling supply system and ensuring sustainability of farmer nurseries, it is crucial to encourage the development of farmer nursery associations and their engagement in marketing. Non-certified small-scale producers have to link up with state nurseries to be viable because of their limited scale of production, investment funds and access to modern technology. The establishment of farmers' associations can mobilize resources, enhance local capacity and knowledge and increase social capital as well as ensuring local empowerment (Koffa and Garrity 2001). Locally-controlled nursery associations can become qualified for certification of production and marketing and be entitled to gain contracts from government, but more importantly they will enrich emerging local seedling markets and improve the quality of seedling in these markets. This will eventually improve the accessibility of high quality germplasm for smallholder farmers. However, much investment and facilitating from the government is required to support training, technology development, provision of market information, and provision of incentives for small-scale seedling production.

Conclusion

Decentralization reforms in the forest sector in Baoshan have supported small-scale forestry development, particularly liberalization of state nurseries, and enabled development of collective and individual nurseries. However, various forms of nurseries are needed to meet the increasing diversification of local demands for planting materials. This would require deeper decentralization reforms in the tree seedling supply system for supporting community-based nurseries and farmers'

nursery associations. In this respect, it is crucial to overcome institutional and technological barriers to improve the certification scheme, enable technology innovation and development of the incorporation between scientific and local knowledge in nursery research, and improve the governance of marketing in terms of information and the bidding system. The current challenge to improve the tree seedling supply system for supporting small-scale forestry in developing countries lies not only in the investment of technology and finance, but also in the political and socio-economic context for further decentralization reforms.

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