Tree Seed Procurement-Diffusion Pathways in Wonogiri and Ponorogo, Java: Indonesia's main source of tree seed

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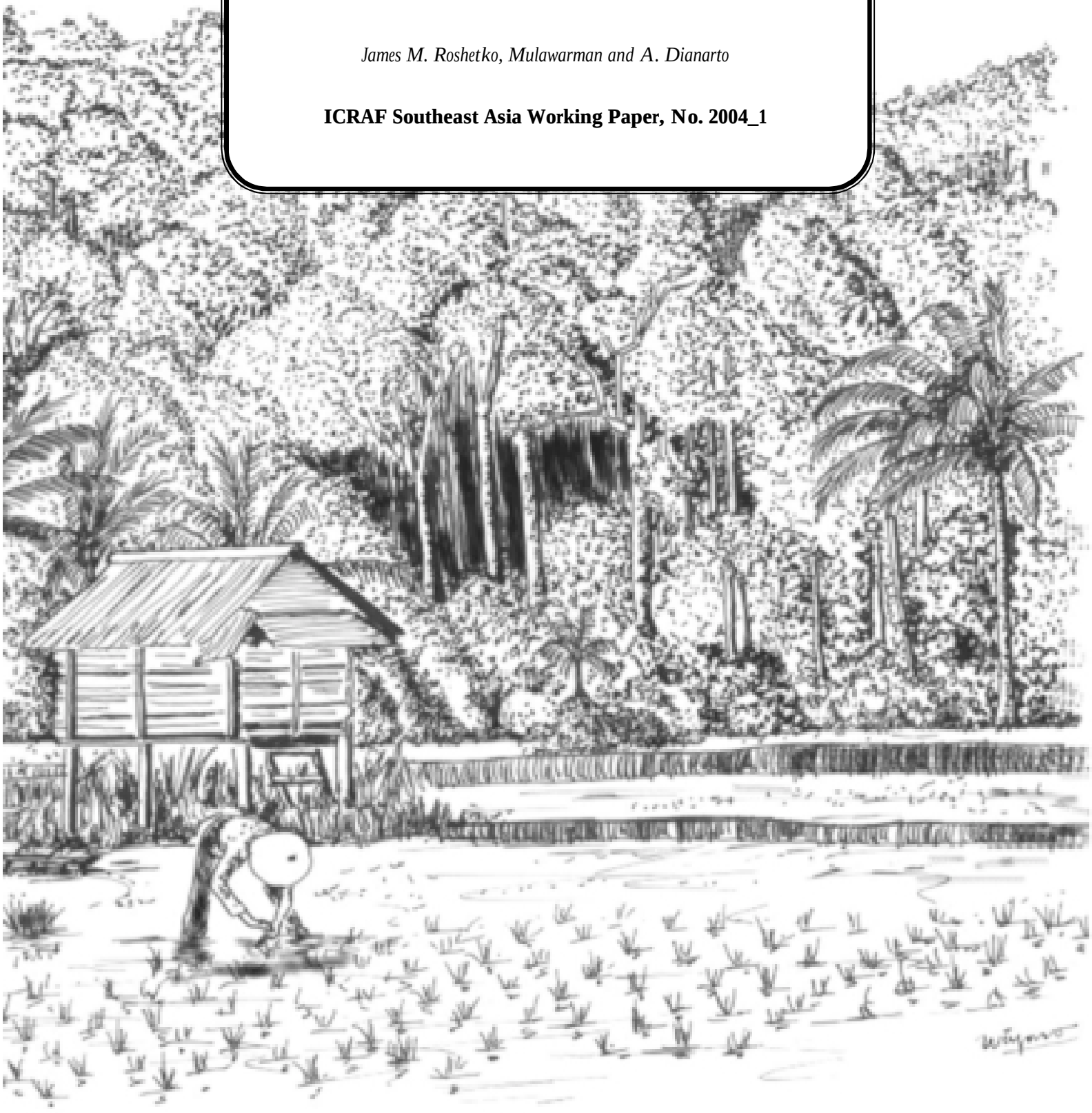

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Abstract

Wonogiri, Central Java and Ponorogo, East Java are neighboring districts (kapubatens). Forty-two percent of their land area is covered with secondary forests of naturalized exotic tree species that are common components of governmental land rehabilitation programs. The seed suppliers operating in the Wonogiri-Ponorogo area represent only 9% of the suppliers in Indonesia yet they possess 90-80% of the national tree seed capacity. Wonogiri-Ponorogo suppliers procure and sell 1510 tons of seed annually. Twenty-four percent of this total (362 tons) is exchange between suppliers; 1148 tons are sold to customers across Indonesia; a small fraction is exported. Seventy-two percent of the seed sold (826 tons) is collected in the Wonogiri-Ponorogo area. The remainder originates in Sumatra, Madura and Nusa Tenggara. In Wonogiri-Ponorogo tree seed is collected by farmers on contract for seed assemblers or seed companies. Assemblers link farmer collectors with seed companies and middlemen, who sell seed to customers. Government agencies purchase 75% of the seed. Cover crop species, Gmelina arborea, Tectona grandis *and* Leucaena leucocephala *account for the 85% of the total seed sold. In general seed collection practices are poor, indicating a negative impact on seed quality. Fortunately, the sheer volume of seed collected in Wonogiri-Ponorogo assures that it comes from a large number of unrelated trees over widely dispersed locations. Simple seed collection guidelines would help farmer improve their seed collection practices and the genetic quality of seed collected. A commitment to seed quality by all agents and customers is required to make such guidelines functional and acceptable. Seed procurement and diffusion generate significant income for all seed agents. As the dominant agents who facilitate most of the activities and inputs required to move seed through the pathway from forest to customers, companies benefit the most. Based on the reported quantities of seed sold, companies' and middlemen's annual revenues are Rp 765 million to Rp 22 million (US $90,000 to $2600). These estimates must be adjusted by subtracting fixed costs, depreciation, extra-legal fees and non- payments (which occurs frequently), to obtain an estimate profits. Accurate records or estimates of these costs are not available. Farmers are the most numerous agent, an estimated 22,500 farmers are involved in seed collection activities annually. They earn incomes of Rp 795,000 to Rp 275,000 from seed collection annually, 66-33% of their 3-month dry-season income. Farmer families living near seed companies earn additional income by processing seed*

Introduction

Government agencies, industrial forestry companies, and numerous non-government organizations (NGOs) and farmer groups throughout Indonesia are involved with reforestation or other tree-planting activities. All of these groups can make important contributions to rehabilitating the estimated 15.1 millions of hectares of degraded land in Indonesia (MOF 2001). The Government of Indonesia (GOI) has set an ambitious target of reforesting 3 million hectares during the 5-year period of 2003-2007 (Fauzi Mas'ud and Murniati 2003). The success or failure of all tree-planting activities depends on many factors. The most important biological factor is *tree seed quality and quantity*. Seed quality determines the upper limits of yield and the productivity of labor, fertilizers and other inputs (Cromwell et al 1992, Cromwell 1990). In absence of other inputs, quality seed will enhance growth and productivity, particularly on degraded sites (Simons et al. 1994). Adequate quantities of seed assure planting targets can be achieved. Unfortunately, the availability of adequate quantities of quality tree seed is often limited. Non-government organizations (NGOs) and farmers groups active with tree planting activities in Indonesia lack access to tree seed of sufficient quantities and quality (Roshetko 2001). Many projects and government offices face similar shortages. In the past, a paucity of information regarding tree seed suppliers exasperated the seed shortage problem. The publication of a directory of Indonesian tree seed suppliers (Roshetko et al. 2003) has helped fill this information gap.

Wonogiri, Central Java and Ponorogo, East Java – separated by only 75 kilometers – are widely acknowledged as the main source of tree seed in Indonesia. Large areas of these districts are covered with secondary forests, composed of the naturalized exotic species that are primary components of government reforestation and private tree-planting programs. Wonogiri-Ponorogo is centrally located in Java – the population, financial and government center of Indonesia. In the 1980's a locally operated tree seed procurement and diffusion system (pathway) evolved in Wonogiri-Ponorogo to serve the national land rehabilitation effort. Understanding the operation, linkages and capacity of this seed pathway is a vital first step in evaluating the quality and quantity of the tree seed available to seed users in Indonesia. To develop such an understanding a study was conducted in Wonogiri-Ponorogo to: i) document the local tree seed collection-diffusion pathway; ii) assess the quality, quantities, and flows of seed collected and distributed; iii) identify principal species for which germplasm is collected and sold; and iv) estimate the economic impact of seed collection activities on the various seed agents.

Methodology

Geographic description of survey area

Wonogiri and Ponorogo are neighboring districts (*kabupaten*) and share similar ecological characteristics. Elevations are generally between 100 and 600 meters; with Ponorogo including a mountain range that rises to 2500 meters. Mean annual temperatures are 24°-32°C in the lowlands and 18°-26°C at higher elevations (BPS Ponorogo 2000; PBS Wonogiri 2000). Annual rainfall is about

1900 mm with higher intensities between October and June. July through September is the dry season with rainfall generally below 50 cm/month. Typical of east-to-west gradients in Java, Ponorogo is hotter and drier than Wonogiri. Upland soils are lithosols of limestone origins, well drained and depleted of nutrients. Lowland soils, of volcanic origins, support productive irrigated rice systems that yield 3 crops per year. Upland cropping systems (corn, upland rice or cassava) are less productive and profitable due to inherently infertile soils and reliance on rainfall. As agricultural yields declined and timber markets developed, farmers and government agencies converted fallowed/abandoned uplands fields to tree farming systems. Today 42% of the two districts are covered with secondary forests – homegardens, community forests, and state plantations – composed of naturalized exotic timber species. A summary of landuse in Wonogiri and Ponorogo is provided in Table 1.

Table 1. Landuse in Wonogiri and Ponorogo (BPS Ponorogo 2000; PBS Wonogiri 2000).

Land use	Wonogiri		Ponorogo	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Rice field	30,701	16.85	35,000	25.55
Dry land farming	61,011	33.48	30,908	22.56
Home garden	36,026	19.77	20,926	15.28
Community forest	12,879	7.07	-	-
State forest	16,268	8.93	46,990	34.30
Other	25,351	13.91	3,154	2.30
Total land area	**182,236**	**100**	**136,978**	**100**

Survey procedures

A multi-stage purposive sampling method was use to select respondent representing the various categories of agents involved in the Wonogiri-Ponorogo tree seed pathways. First, ten local seed companies and middlemen were identified from a list of tree seed supplier compiled by ICRAF; Winrock International; the Danida-funded Indonesian Forest Seed Project (IFSP); and the Directorate of Forest Tree Seed (DFTS), Ministry of Forestry. Based on information provided by seed companies and middlemen, local seed assemblers were identified. Seed collectors were identified based on information provided by local assemblers and seed companies. A total of 71 respondents were interviewed: 7 seed companies; 3 middlemen; 11 seed assemblers; and 50 seed collectors. Distribution of respondent by district is provided in Table 2.

Table 2. Distribution of survey respondent by district.

Respondents	Wonogiri	Ponorogo
Seed companies	4	3
Seed middlemen	1	2
Local seed assemblers	4	7
Seed collectors	28	22
Total Respondents	***37***	***34***

A semi-structured survey was used to collect the following data: social economic condition of respondents; source of seed; seed collection, processing, handling and storage procedures; quantity of seed procured and sold annually; priority species as indicated by seed volume; seed flow between seed agents and customers; and income generated from seed procurement and diffusion activities. Descriptive analysis was used to extract information from survey data.

Results

Seed agents. Four types of seed agents were identified as part of the pre-survey process: *farmer seed collectors*, *seed assemblers*, *seed middlemen*, and *seed companies*. They vary greatly in profile. Farmer collectors are 26 to 65 years old, with an average age of 42. Ninety-four percent of the farmer collectors have a primary school education or less. The farmer collectors own landholdings that are insufficient to support their families; 96% own less than 0.5 hectare. Seed assemblers are 36 to 56 years of age. Sixty-four percent have a primary school education or less; the remaining 36% have an intermediate or high school education. Most have insufficient landholdings to support their families; 64% have less than 0.5 hectare and 27% 0.5-1.0 hectare. Seed middlemen are 45-51 years of age. Their education level is similar to assemblers, 67% have a primary school education and 33% a high school education. Middlemen own an average of 3 hectares and all are either district or village officials with strong linkages to local seed and seedling customers. Seed company owners are 56-65 years old and all have a high school or university education. They have large landholdings; 43% owned an average of 3 hectares and 57% own 5-10 hectares. Eighty-six percent of the owners are district or village officials.

Pathway linkages. Farmers sell 54% of the seed collected to companies and 46% to assemblers. Eighty percent of the seed purchased by assemblers is then sold to companies and 20% to middlemen. Companies sell 24% of their seed to middlemen or other companies; the remainder is sold to seed customers. Middlemen sell 100% of their seed to customers. Farmers sell some tree seed to customers in local markets; infrequently assemblers sell seed directly to consumers. However, only limited volumes of seed are sold through these two channels. Figure 1 depicts linkages between Wonogiri-Ponorogo seed agents and the volumes of seed exchanged. Details concerning volumes are reported below.

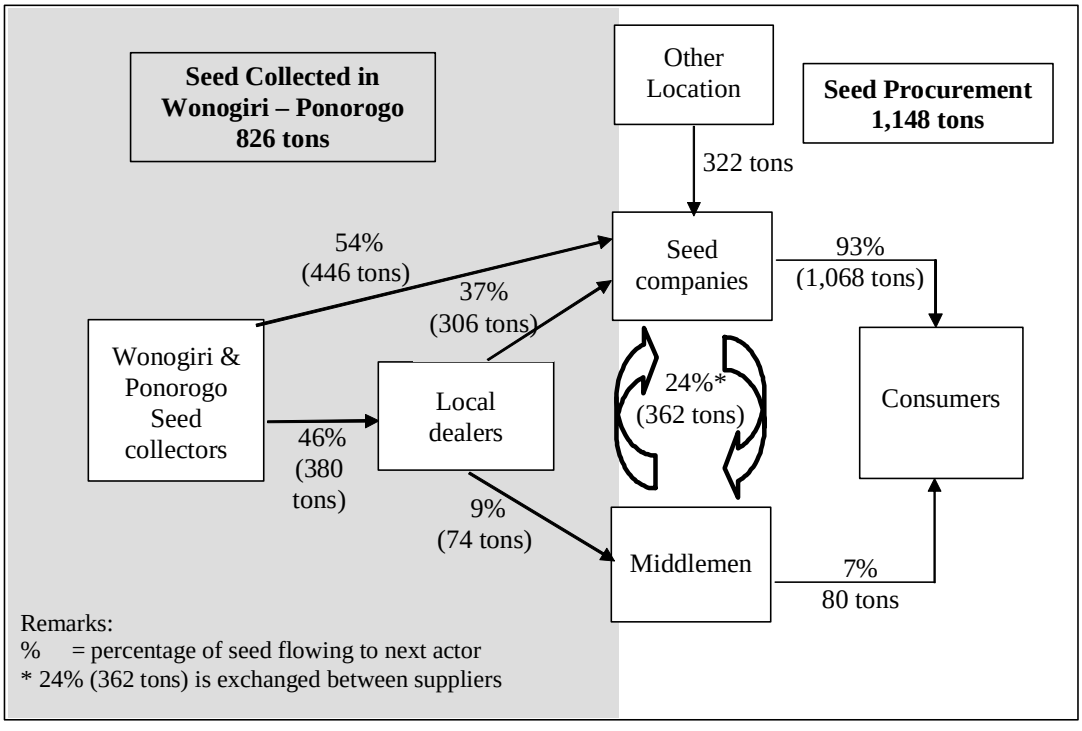
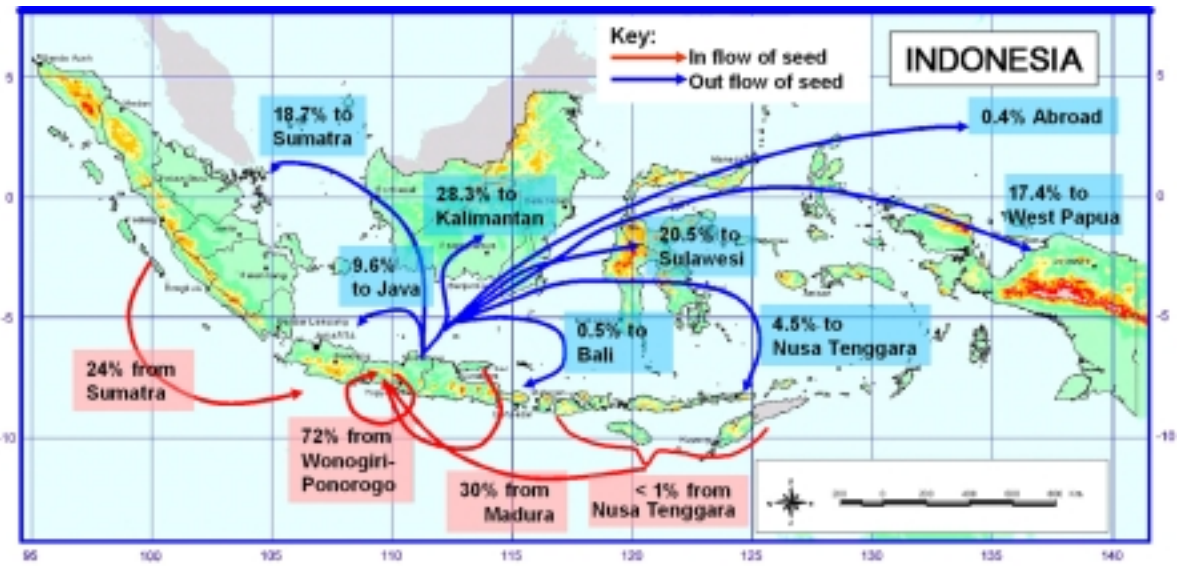


Figure 1. Seed procurement and diffusion pathways in Central and East Java.

Seed quantities, flow and customers. Seed suppliers (companies and middlemen) estimate they procure and sell 1510 tons of tree seed annually. Twenty-four percent of this total (362 tons) is exchanged between suppliers. Of the 1148 tons sold to seed customers, 72% (826 tons) is collected by farmers in the Wonogiri-Ponorogo area; 24% (275 tons) originates from Sumatra; 3% (35 tons) is imported from Madura; and less then 1% from Nusa Tenggara. The Wonogiri-Ponorogo seed is primarily of naturalized exotic tree species; the Sumatra seed is of cover crop species; the Madura seed is exclusively *L. leucocephala*; and the Nusa Tenggara seed is of various tree species. Once processed 28.3% (325 tons) of the seed is sold to customers in Kalimantan, 20.5% (236 tons) to Sulawesi, 18.7% (215 tons) to Sumatra, 17.4% (200 tons) to Irian Jaya, 9.6% (110 tons) to other locations in Java, 4.5% (52 tons) to Nusa Tenggara, 0.5% (6 tons) to Bali and 0.4% (5 tons) abroad. District Forest and Estate Crop Offices purchase 46% of the seed; state forest companies 29%; other state and private companies (including development projects and firms implementing projects) 20%; private nurseries 3%; farmers 2% and NGOs 0.7%. Figure 2 illustrates the flows of seed in and out of Wonogiri-Ponorogo area.



Seed sources, mother trees and collection methods. Forty-four percents of farmers collect seed exclusively from state plantations, 36% collect seed exclusively from farmland, and 20% collect from both state plantations and farmland. Farmers select mother trees according to a limited set of criteria. Tree accessibility and the presence of abundant mature seed crops are the key criteria, used by 90% and 78% of farmer collectors respectively. Sixty-six percent of farmers collect seed from big trees, regardless of tree health or phenotypic quality. Only 8% of farmers select mother trees that are free of pests and diseases, and only 4% select mother trees according to timber quality characteristics. Farmers collect seed from 2-5 trees a day. Over the entire season 68% of farmers collect seed from 40-200 trees annually; 12% from 20-40 trees; and 20% from less than 20 trees. Only 4% of collectors select mother trees that are separated by 100 meters. Regarding seed selection criteria: 80% of collectors select mature seed, 74% select fruit that are full of seed, 6% select seed that is free of pests and diseases, 4% select large seed; and 4% select dry seed. Table 3 provides a summary of mother tree and seed selection criteria. Eighty percent of farmers collect seed directly from trees, 20% collect seed from the forest floor and 18% of farmers collect seed from both trees and the forest floor. Pole pruners and hooked bamboo poles are used to collect seed from trees. However, no tree climbing safety equipment is used, nor are tarps used to facilitate the gathering of fallen seed.

Table 3. Mother tree and seed selection criteria used by farmer collectors.

Seed tree selection		Number of seed trees		Seed collection	
Criteria	**% of farmers**	**Seed trees**	**% of farmers**	**Criteria**	**% of farmers**
Easy to reach	90	**< 20**	20	**Mature seed**	80
Abundant seed	78	**20-40**	12	**Full seed**	74
Tall trees	66	**40-60**	14	**Free of pests & disease**	6
Free of pests & disease	8	**60-100**	22	**Large size seed**	4
Good timber quality	4	**100-200**	20	**Dry seed**	2
		>200	12		

Seed processing, shipping and documentation. After collection green fruits are stored in sacks for 1-2 days to after-ripen. Fruit processing and seed cleaning requires 1-2 days, after which the seed is sun dried for an additional 1-2 days. Processing, cleaning and drying reduces seed volume by 5-10% for most species, by 20% for some species (*L. leucocephala*, *G. arborea*, *Tephrosia candida*, *Pinus merkusii*, *Anacardium occidentale* and *Dalbergia* sp.), and as much as 20-50% on some occasions (*S. macrophylla*). Seed is normally shipped to customers within 1-14 days of processing. Most seed is shipped in sacks, shipments intended for destinations outside of Java are double-sacked. Large shipments are delivered to customers by seed company trucks; costs are Rp 950,000 per truck within Java and Rp 2,500,000-3,500,000 per truck to Sumatra. Smaller shipments are sent through shipping services. Shipments are usually delivered in 1-2 days in Java and 3-6 days outside of Java. Very small shipments and high value seed is sent by courier service, overnight in Java and within a few days outside of Java. The cost of shipping and courier service is charged to customers at costs. Generally, no seed documentation is provided with shipments.

Principal Species. Suppliers procure and sell the germplasm of 71 species. Their primary product is seed. The principal species of which seed is sold are listed in Table 4. Cover crop species, *Gmelina arborea*, *Tectona grandis* and *Leucaena leucocephala* account for the 84.6% of the total seed volume sold. Seed of indigenous species equals less then 1% of the seed sold. Suppliers also sell approximately 500,000 seedlings per year. The key species for which seedlings are sold are identified in Table 5. *Cocos nucifera, Eugenia aromatica, Nephelium lappaceum,* cover crops and *Swietenia macrophylla* account for 66.0% of the seedlings sold.

Table 4. Principal species of seed sold by Wonogiri-Ponorogo suppliers.

Species	% of total	Species	% of total
Cover crops*	25.0%	*Gliricidia sepium*	2.7%
Gmelina arborea	24.1%	*Swietenia macrophylla*	2.6%
Tectona grandis	20.1%	*Calliandra calothyrsus*	2.4%
Leucaena leucocephala	15.4%	*Paraserianthes falcataria*	1.0%
Aleurites moluccana	4.4%	Indigenous tree species	>1%
		Total	***97.7%***

**Mainly Centrocema pubescens, Calopogonium sp, Crotolaria mucronata, and Mucuna pruriens.*

Table 5. Principal species of seedlings sold by Wonogiri-Ponorogo suppliers.

Species	% of total	Species	% of total
Cocos nucifera	20.6%	*Gnetum gnemon*	7.9%
Eugenia aromatica	12.1%	*Citrus* sp.	6.1%
Nephelium lappaceum	12.1%	*Parkia speciosa*	5.3%
Cover crops*	11.1%	*Mangifera indica*	5.1%
Swietenia macrophylla	10.1%	*Aleurites moluccana*	4.0%
		Total	***94.4%***

** Mucuna sp (4.0%) and Tephrosia candida (7.1%).*

Economic impact. Based on reported volume of seed sold, suppliers' annual revenues, less seed procurement and processing costs, vary from Indonesian Rupiah (Rp) 765 million to Rp 22 million (US $90,000 to $2600). Total annual revenues for all Wonogiri-Ponorogo seed suppliers are Rp 2.4 billion ($280,000). These revenue estimates do not consider fixed costs (vehicles, rents, maintenance costs, miscellaneous equipment and supplies, daily operating expense, wages/salaries for family employees), depreciation and other expense. Seed companies employ 2-4 permanent and 4-20 part-time workers. Estimates indicate that as a group these employees earn approximately Rp 55,000,000 ($6500) annually from processing seed; averaging Rp 525,000 to 330,000 per employee ($62 to $39). Farmer collectors estimate that they earn Rp 795,000 to Rp 275,000 from seed collection during the annual 3-month dry-season ($94 to $32). Sixty-six percent of farmer collectors earn 33% of their dry-season income from seed collection; 24% earn 50% of their dry-season income; and 10% earn 66% or more of their dry-season income.

Discussion

Farmer collectors, seed assemblers, seed middlemen and seed companies are the agents involved in the Wonogiri-Ponorogo seed procurement-diffusion pathway. They conduct the activities (collection, procurement, transport, processing, storing, selling) and provide the inputs (labor, skills, information, capital) needed to move seed through the pathway from trees to customers. Agents are progressively older, better educated, and more economically secure at each step along the pathway from collector to company owner. This progression coincides with a stronger position within the seed pathway. Seed companies operate as family businesses and are the pathways dominant agent. They facilitate most of the activities and inputs required. Companies are responsible for seed processing, a key value-adding activity, that enables them to earn additional profit margin. Companies protect their dominant role by maintaining strong linkages with farmer collectors and assemblers (procurement networks); and strong linkages with customers at local, provincial, national and international levels (diffusion networks). Their primary customer base is government organizations that purchase seed in large quantities, but they do not hesitate to fill small orders from other customers. The role of middlemen is less dynamic. They simply transfer seed from other agents to customers, without enhancing seed value. Middlemen maintain strong linkages with local government customers, which enable them to capture profit. Seed assemblers are not independent entrepreneurs. They generally work for a single company or middleman. Assemblers may collect seed themselves, but their main role is to facilitate networks of farmer collectors. When procuring seed for middlemen, they are able to capture more benefits by processing seed. Farmers are in the weakest position in the pathway. They collect seed and accept the price offered by assemblers and companies. The linkages, activities and inputs of the various seed pathway agents are depicted in Figure 3.

The annual seed procurement-diffusion process starts between July and September when orders are received by suppliers from customers, some orders are received as late as December. Most seed is collected July through September. Companies and assemblers operate in specific territories. All companies and assemblers recognize the existence of these *seed procurement territories*. If one company or assembler has an established operation in a village, others generally will not purchase seed directly from farmers in that location. On occasions when a company's network of seed procurement territories is not able to fill all orders, the company purchases the shortfall of seed from other companies or unassociated assemblers. Prices depend on market conditions and personal relationships, but generally are higher then the company would pay to assemblers or farmers in its own territories. The recognition of these seed territories operates as a trade syndicate, limiting farmers' options and allowing companies to set seed prices. Occupying weaker positions in the pathway, assemblers and middlemen generally follow the price range set by companies. The prices set by companies are greatly influenced by government customers who purchase over 75% of seed volumes. Government customers are very price conscious, showing a preference for large quantities of inexpensive seed.

Agents	Collectors	Assemblers	Seed companies	Middlemen	Customer
Linkages (with)		Collectors	Collectors, Assemblers, Customers	Assemblers, Customers	
Activities	Collection, Processing, Transport	Procurement, Processing (minimal)	Procurement, Transport, Processing, Storage, Sales	Procurement, Sales	Purchase
Inputs	Labor, Skill	Information	Laborers, Skills, Information, Capital	Information	

Figure 3. Linkages, activities and inputs of the various agents involved in the Wonogiri-Ponorogo seed pathway.

Most farmers receive orders before collecting seed, only 32% collect seed on their own initiative anticipating annual demand. Farmers collect seed from both state forestland and farmland. Permission is generally sought from land managers or owners before seed is collected. There is little data available concerning the origins of most of these secondary forests. As with all undocumented seed, it is best to assume that these planted forests have a narrow genetic base. Farmers' seed collection practices show little appreciation for genetic quality. They select seed sources and mother trees that are nearby, easy to access and have abundant seed crops. They collect seed from as few trees as possible. Fortunately, the sheer volume of seed collected in Wonogiri-Ponorogo (and by individual farmers) assures it comes from a large number of unrelated trees in widely dispersed locations. We can safely assume that significant narrowing of the genetic base is not occurring. More worrying is collectors' disregard of tree quality as the most important criteria for seed source and mother tree selection. Collectors' preference for seed quantity over source/tree quality indicates negative selection criteria. This preference conforms to market demand. Other agents and customers are concerned with seed quantity and price, not seed quality. They generally do not request farmers to collect seed according to proper guidelines. Findings in Wonogiri-Ponorogo are similar to those in the Philippines

(ASC 1993; Koffa and Roshetko 1999) and indicate time constraints, a lack of knowledge and negative incentives (quantity over quality) results in farmers adopting poor seed collection practices. Seed collection guidelines developed for farmer-specific conditions stress the following key criteria: select good quality seed sources and mother trees; collect from a minimum 30 trees that are a minimum of 50 m apart (Dawson and Were 1997; Mulawarman et al. 2003). These guidelines are simple and adaptable by farmers. They assure seed is collected from an adequate number of best quality trees in a population and that the seed represents a broad genetic diversity (unrelated parents). By comparison current practices indicate that the seed collected is of average to below-average genetic quality. Studies in the Philippines show that farmer who demonstrate poor seed collection skills (Koffa and Roshetko 1999), develop technically sound collection practices following training (Tolentino et al 2002; Koffa and Garrity 2001). Farmers report guidelines are easily to implement and required little additional work. A strong demand for tree seed, a commitment to collect quality seed and a reputation as suppliers of quality seed encourage farmers to adapt proper tree seed collection methods (Koffa and Garrity 2001). Experience with farmers and NGOs in Indonesia yield similar conclusions to those of the Philippines (Roshetko 2002).

When seed demand or price for a particular species is high and few local sources exist, Wonogiri-Ponorogo companies have established seed sources. One company provides farmers with seed, fertilizers, and wages to produce seed of cover crop species on contract. Key cover crop species (see Table 4) produce seed within a year (Hanum et al. 1997) providing companies a quick return on investment. Most companies have planted stands of trees on their own land, through government land rehabilitation programs, that function as seed sources. These stands provide only a fraction of the seed collected by companies by demonstrate a long-term seed procurement strategy. The most interesting case of local seed source establishment involves *E. cyclocarpum*, which was a major component of the national regreening program in the 1980's. With seed demand high and few seed sources within the country, seed price was a lucrative Rp 60,000/kg (US $30 at the time). A supplier rented farmers' lands to establish stands of *E. cyclocarpum* with support from the national rehabilitation program. Farmers were encouraged to intercrop the *E. cyclocarpum* stand and retain ownership of the *E. cyclocarpum* seed crops. The supplier has first rights to purchase the seed. Both farmers and supplier benefit from this relationship, a unique example of *private sector–farmer collaboration* utilizing a national reforestation program to establish tree plantations for the long-term objective of seed production. The production of appreciable quantities of *E. cyclocarpum* seed begins when trees are 25 years old (Hughes and Stewart, 1990). The *E. cyclocarpum* seed sources described are just entering their period maximum productivity.

To reduce the weight of the seed carried home, farmers initiate seed extraction and cleaning of species that are easily processed, (*L. leucocephala*, *T. grandis*, *S. macrophylla* and *C. calothyrsus*). These activities are considered part of the collection process, for which collectors receive no additional payment. The amount of seed that can be collected per day varies greatly by collector, tree species and conditions of the seed source. Collectors and assemblers offered the following generalization for which there are many exceptions: *T. grandis* 1 sack (20-25 kg)/day; *S. macrophylla* 1 sack (10 or more kg)/3-5 days; *Leucaena, Gliricidia* or *Calliandra* 3-5 kg/day. Companies conduct seed processing by employing local farmers on a daily wage or contract basis. Daily wages are Rp 7,000 for female workers and Rp 10,000 for male workers to clean/dry/sort 100-200 kg/day or pack/store 200-500 kg/day. Contract wages average Rp 15,000/ton to clean/dry/sort and Rp 7,500/ton to pack/store regardless of gender. The apparent differences between daily and contract rates are misleading. The daily rate is gauged for leisurely work. Through diligent effort workers can easily clean/sort 1 ton/day or pack/store 2-3 tons/day. People in search of money to support their families prefer contract rates. Seed processing is based on a traditional volume unit called a *tompo*, just over 4 kg. In practice, companies calculate a *tompo* as 4 kilograms and pay workers accordingly. Companies say the small advantage gained with each tompo processed is to compensate for the 10-20% loss in seed volume resulting from processing. Employees are aware of the volume discrepancy. They accept the condition because they are satisfied to have employment that suits their conditions. With the

exception of *T. grandis*, seed is not graded as no premium is paid for better quality seed. If higher quality is requested, companies will grade seed and increase the price to cover their investment.

Seed is shipped to customers as soon as possible, usually within 2 weeks. In general, shipments are not accompanied by seed quality documents. One company does provide technical information on seed pre-treatments, seed sowing and seedling care. If customers request seed documentation some companies provide letters from Forest Seed Centers (BPTH, Balai Perbenihan Tanaman Hutan) certifying that seed samples from the company have been tested for purity and viability. Such letters are largely per functional. No guarantee is implied and customers have no recourse if seed quality does not match that indicated. National tree seed certification procedures and regulations are currently under development by the Directorate of Forest Tree Seed, Ministry of Forests (DGLRSF 2002). All companies have facilities to store seed that is not sold immediately. These facilities consist of cement rooms or wooden structure. Conditions are generally clean, cool, dry, well-ventilated, well-lit, and protect seed from direct sunlight. Seed is stored in burlap or plastic sacks, bamboo baskets, boxes or other containers; and stacked on shelves, pallets or directly on the floor. Sacks placed on the floor degrade more quickly from pests, moisture and physical damage. These storage conditions are adequate for periods up to 12 weeks, but not much longer. If seed is not sold after 6 months companies employ one of the following measures. i) Seed is redried and sorted. Poor quality seed is burned and the good quality seed is sold the following year. ii) Seed is sold to make medicine (*S. macrophylla*), mosquito repellent (*A. indica*) or other products. Unsold seed is burned. iii) Seed is stored until the following year, when it is mixed with new seed at a rate of 1 to 10 and sold. Long-term storage (over 6 months) of high-value seed is achieved by using sealed glass jars wrapped in cotton cloth or sending seed to the BPTH in Bandung for cold storage.

Seed collection and processing activities are dominated by women. Forty-eight percents of seed collector respondents are female farmers; the other 52% are husband-wife teams. None of the male respondents are active in seed collection without the partnership of his wife. There are clear job divisions between men and women's seed collection roles. Men climb trees, directly collect seed or knock it to the forest floor, where women collect the seed and discard the debris. Women collect seed directly from short and medium stature trees without climbing. Husband and wife pairs collect seed from *L. leucocephala, S. macrophylla, E. cyclocarpum* and *P. falcataria.* Women collect the seed of *G. sepium, T. grandis, G. arborea, Albizia* sp and *Acacia* sp without assistance. Men carry the seed home from the forest and perform other tasks requiring heavy lifting. Post-collection activities – seed extraction, cleaning, drying, and sorting – are conducted primarily by women. We estimate a minimum of 75% of the seed collection and processing is conducted by women. Running the seed companies is also the domain of women. The wives of the owners manage six of the seven seed companies surveyed. These women are responsible to: develop and maintain relationships with farmer collectors and assemblers; place orders with collectors and assemblers; organize and monitor seed processing; manage permanent and part-time employees; conduct other daily requirements; and organize seed shipments. The husband-owners develop and maintain the all-important governmental linkages, the customers who buy the majority of the seed. All the seed assemblers and middlemen in Wonogiri-Ponorogo are men.

Wonogiri-Ponorogo suppliers sell 1149 tons of tree seed annually and dominate the national tree seed market. One hundred twenty-eight enterprises are listed in Indonesian directory of tree seed suppliers (Roshetko et al. 2003). The 7 largest suppliers are located in Wonogiri-Ponorogo. They report the capacities to supply 300,000 to 50,000 kg of seed/year. This capacity is in addition to anticipated annual orders from established customers. The largest suppliers outside the Wonogiri-Ponorogo area report capacities of only 10,000 kg/yr. The average capacity of these non-Wonogiri-Ponorogo suppliers is 2200 kg/yr. Analysis of the information provided by Indonesian seed suppliers shows that Wonogiri-Ponorogo suppliers possess 90-80% of the national tree seed supply capacity. Experience indicates that most non-Wonogiri-Ponorogo suppliers sell seed at the local or provincial level. Several

Indonesia-based forest industries and research organizations produce improved-quality seed of a limited number of tree species, including *A. mangium, T. grandis, S. macrophylla, P. falcataria, G. arborea, G. sepium, Pinus merkusii* and *Eucalyptus* species (IFSP personal communication; DLRSF 2003). This improved-quality seed is of limited quantity and expensive. It is primarily sold or exchanged within the formal tree seed sector – research organizations, government agencies and forest industries. The distribution of improved-quality seed in Indonesia conforms to regional patterns (Harwood et al. 1999).

Suppliers provide the germplasm of 71 species both seed and seedlings (Table 6). Most companies will procure seed or seedlings of any species requested by customers. Middlemen are generally not interested in making special efforts unless the order is large. There is a noticeable difference between the species sold as seed and seedlings. Seedlings, produced on contract by farmers, are mainly of estate crops and fruit species. Seed sales focus on exotic timber and leguminous tree species, the main components of government land rehabilitation programs, which purchase 75% of the seed. Cover crops and *S. macrophylla* are commonly sold as both seed and seedlings. *Leucaena leucocephala*, *T. grandis*, *G. arborea* and cover crops are the most profitable species. These four species/groups of species are traded in large quantities, accounting for 92% of seed company income. Estimated profits margins for individual species vary from 0.81 (*Melaleuca leucadendron*) to 0.03 (*Pinus merkusii* and *Prosopis* sp.). Species with profit margins (purchase price/sale price) of 0.50% or above are *A. mangium, Acacia oraria, Azadirachta indica, Ceiba petandra, Dalbergia latifolia, Leucaena leucocephala*, *Melaleuca leucadendron, Senna siamea, Shorea* sp, *T. grandis* and *Tamarindus indica.* Species with a high value per kg are *A. mangium, Acacia oraria, Dalbergia latifolia, Melaleuca leucadendron, Pinus merkusii, Prosopis* sp., *Tamarindus indica* and *Senna siamea*. A high value per kg may compensate for a low profit margin per volume. Table 7 provides purchase and sale prices for the seed of key species as reported by Wonogiri-Ponorogo seed companies.

Table 6. Species and germplasm type sold by Wonogiri-Ponorogo seed suppliers.

Species & germplasm type		Species & germplasm type		Species & germplasm type	
Acacia Arabica	1	*Cocos nucifera*	2	*Mucuna* spp	b
Acacia auriculiformis	1	*Crotalaria mucronata*	1	*Nephelium lappaceum*	2
Acacia mangium	1	*Dalbergia latifolia*	1	*Paraserianthes falcataria*	1
Acacia tomentosa	1	*Dalbergia sisso*	1	*Parkia speciosa*	2
Acacia oraria	1	*Dolichos lablab*	1	*Parkia javanica*	2
Acacia villosa	1	*Durio zibethinus*	2	*Persea americana*	2
Albizia saman	1	*Enterolobium cyclocarpum*	1	*Pinus merkusii*	1
Albizia procera	1	*Eucalyptus alba*	1	*Prosopis juliflora*	1
Aleurities moluccana	2	*Eugenia aromatica*	2	*Prosopis* spp	1
Anacardium occidentale	2	*Eugenia polyantha*	2	*Ricinus communis*	1
Anthocephalus cadamba	2	*Ficus conciliarum*	1	*Santalum album*	b
Artocarpus heterophylla	2	*Filicium decipiens*	2	*Schleichera oleosa*	1
Averhoa carambola	2	*Flemingia macrophylla*	1	*Senna siamea*	1
Azadirachta indica	1	*Gliricidia sepium*	1	*Sesbania grandiflora*	1
Caesalpinia sappan	1	*Gmelina arborea*	1	*Shorea* spp	1
Calopogonium mucunoides	1	*Gnetum gnemon*	2	*Spondias* spp	2
Calopogonium spp	1	*Hibiscus tiliaceus*	2	*Swietenia macrophylla*	b
Calliandra calothyrsus	1	*Leucaena leucocephala*	1	*Tamarindus indica*	1
Canarium commune	2	*Mangifera indica*	2	*Tectona grandis*	1
Canavalia ensifloris	1	*Manikara zapota*	2	*Tephrosia candida*	b
Ceiba petandra	1	*Melaleuca leucadendron*	1	*Terminalia cattapa*	2
Centrocema pubescens	1	*Melia azedarach*	1	*Toona sureni*	2

Species & germplasm type		Species & germplasm type		Species & germplasm type	
Centrocema spp	1	*Metroxylon sagu*	1	*Zapoteca tetragona*	1
Citrus spp	2	*Mucuna pruriens*	B		

Germplasm type: 1 = seed; 2 = seedling; b = both.

Table 7. Purchase and selling price for seed of key species.

Species	Purchase Price	Selling Price	Species	Purchase Price	Selling Price
Acacia Arabica	1,750	4,000	*Gliricidia sepium*	1,950	3,000
Acacia auriculiformis	3,500	5,000	*Gmelina arborea*	4,500	6,500
Acacia mangium	5,000	17,500	*Leucaena leucocephala*	2,100	9,500
Acacia tomentosa	2,500	6,000	*Melaleuca leucadendron*	3,000	40,000
Acacia oraria	5,000	14,500	*Melia azedarach*	2,000	3,500
Acacia villosa	2,500	3,750	*Paraserianthes falcataria*	4,000	6,000
Albizia saman	1,500	1,750	*Pinus merkusii*	37,500	50,000
Albizia procera	3,000	5,000	*Prosopis* spp.	30,000	35,000
Azadirachta indica	1,600	5,250	*Schleichera oleosa*	3,700	8,000
Caesalpinia sappan	2,000	2,500	*Senna siamea*	5,000	12,500
Calliandra calothyrsus	4,000	8,000	*Sesbania grandiflora*	2,000	2,750
Ceiba petandra	500	1,750	*Shorea* spp.	3,000	8,000
Cover crops	1,750	4,000	*Swietenia macrophylla*	3,000	5,000
Dalbergia latifolia	2,500	12,000	*Tamarindus indica*	1,000	10,000
Dalbergia sisso	2,000	3,500	*Tectona grandis*	1,400	3,500
Enterolobium cyclocarpum	2,750	4,500	*Tephrosia candida*	5,000	7,000
Eucalyptus alba	2,000	3,500			

Seed collection and sales generate significant income and profit for all agents involved in the Ponorogo-Wonogiri tree seed pathway. As the dominant agent who facilitates the most activities and inputs, seed companies receive the greatest benefits. Based on the reported quantities of seed sold, seed companies' annual revenues less procurement and processing costs are Rp 765 million to 22 million. To obtain an accurate estimate of profits other expenses must be subtracted from revenues. These other expenses include fixed costs (vehicles, rents, maintenance of facilities, miscellaneous equipment and supplies, daily operating expense, wages/salaries for family employees and casual labor) and depreciation. Additional expenses are *extra-legal fees* involved with selling and transporting seed. Suppliers are family-operated business; records or estimates of these expenses are not kept and available to outsiders. Companies consider the seed trade to be a risky business. They feel they are at a clear disadvantage in all transactions. Their main customers, government agencies, order large volumes of seed but provide no advance payments. Companies have to pay collectors and assemblers for seed on delivery, and make further investments in processing, packaging and shipping. If orders are cancelled companies have no recourse, even when seed has been collected and processed or purchased from other suppliers. Payments are often late or never received. Government officers who order and use the seed may be transfered to new assignments before payment is processed. Newly arrived officers feel no obligation to pay for past activities from their current budgets. It is imperative that companies maintain good relationships with their government and corporate customers. Despite the perceived risks, profits are prosperous. No seed companies consider leaving the business.

Middlemen occupy a strategic linkage between seed supply and customers. This position enables them to capture adequate profits without making significant contributions to the activities or inputs of the seed collection-diffusion pathway. To protect their market position, middlemen are not forthcoming with details concerning their pathway transactions. Middlemen consider the seed business to be profitable. The profits and benefits gained by assemblers are difficult to quantify.

Payments received by assemblers are calculated in a number of different ways. Assemblers may receive a nominal Rp 500 for each kg collected by farmers or a fee of Rp 10,000 per 100 kg. Sometimes they are paid a finders fee of Rp 10,000-20,000 for identifying and facilitating collection per seed source. The same source might be 'identified' in more then one year. If the supply of seed organized by an assembler is particular profitable, a company may give them a television or similar gift. In general assemblers are content with their role in the seed pathways, which is only one of their income-seeking activities. Forty-five percent of assemblers also market spices and furniture, a role similar to their function in the seed pathway.

Farmer collectors are the most numerous seed agent in Wonogiri-Ponorogo. Data regarding the number of farmer collectors does not exist. Several survey respondents reported that in some Wonogiri-Ponorogo villages nearly all adults are involved in tree seed collection activities. Data on one company estimates it employs 450 farmers annually to collect seed. Extrapolation indicates that each year 22,500 farmers may be involved in seed collection activities in Wonogiri-Ponorogo. Tree seed collection occurs during the July through September dry-season when agricultural activities and other economic options are limited. Farmers are available and eager to collect tree seed to enhance their incomes. This large willing labor force and the collusive practice of exclusive seed procurement territories enable seed companies to easily control the price paid to farmers. If farmers demand a higher price, company representatives and assemblers simply approach other farmers to collect seed. Farmer collectors would prefer a higher price for seed, but they appreciate the existing situation. Several farmers commented that before seed companies began operating tree seed had no value. Now it is a valued commodity that augments local incomes. Wonogiri-Ponorogo farmers have limited landholdings and low incomes. Tree seed collection is a major income earner for them, providing 66% to 33% of their dry-season income (Rp 795,000 to Rp 275,000). Assuming an average of 3 persons/family involved in seed collection activities, farmers' estimates of income from seed collection correspond with total incomes for seed collectors calculated from seed volumes collected in Wonogiri-Ponorogo. Processing seed is equally lucrative for farmers living near seed companies, providing Rp 525,000 to Rp 330,000 per employee per dry-season. The number of farmers employed annually by companies to process seed is about 135.

The cash earned from seed collection/processing is controlled by household women and earmarked for a number of specific purposes. All families surveyed prioritize the use of seed-related income to provide daily food needs during the dry-season and to support social commitments, such as weddings, funerals, circumcisions or other community donations. In half the respondent families, the remaining seed-related income is invested in cattle as a form of living bank account. As cattle grow they accrue value and are sold whenever cash is required, commonly to purchase agricultural input or cover family emergencies. When cattle mature or prices are lucrative, they are sold and gold purchased as a new form of savings. Some seed-related income is allocated to provide children with pocket money or to cover regular medical expenses.

Conclusion

Wonogiri-Ponorogo seed suppliers represent only 8% of the suppliers operating in Indonesia, however they possess 90-80% of the national tree seed capacity and are clearly the main source of tree seed in Indonesia. They procure 1510 tons of tree seed annually, 24% of this total is exchange between them. Of the 1148 tons sold to seed users 72% (826 tons) is collected in the Wonogiri-Ponorogo area, 24% (275 tons) in Sumatra, 3% (35 tons) in Madura, and less the 1% in Nusa Tenggara. Most of the seed

is sold to local, provincial, and national customers across Indonesia. About 5 tons (0.4% of the total) is sold abroad annual. Government agencies purchasing more than 75% of the seed and thus have a strong influence over price and species of seed provided. The main species for which seed is sold are naturalized exotic timber species and leguminous tree species, which are popular components of government land rehabilitation programs. A locally evolved system of seed collectors, seed assemblers, middlemen and seed companies conducts seed procurement and diffusion activities in Wonogiri-Ponorogo. Assemblers organize seed collection by farmers for companies and middlemen, who sell the seed to customers. Seed companies facilitate or provide most of the activities and input required to move the seed from the forest to the customers. They are the dominant agent in the Wonogiri-Ponorogo tree seed pathway. The seed is collected from state plantations and farmland. There is little information available concerning the genetic origins of these secondary forests. Genetic studies would be useful to document the existing diversity. Farmers collect seed from trees that are nearby, easy to access and have abundant seed crops, without regard for the quality of the tree. Fortunately, the sheer volume of seed collected in Wonogiri-Ponorogo assures that it comes from a large number of unrelated trees over widely dispersed locations. More worrying is farmer collectors' disregard of tree quality as the most important criteria for mother tree selection. Standard seed collection practices indicate negative selection criteria, but conform to market demand. Other agents and customers are all more concerned with large quantities of inexpensive seed, rather than seed quality. Evidence indicates that simple seed collection guidelines developed for local conditions can help improve farmer's seed collection practices and the genetic quality of seed collected. A commitment to seed quality by all agents and customers is required to make such guidelines functional and acceptable. Seed collection and processing methods in Wonogiri-Ponorogo are low-tech but adequate. Women are indispensable to seed procurement-diffusion in Wonogiri-Ponorogo. They conduct 75% of the seed collection and processing activities and are responsible for the daily management of most of the seed companies. Seed procurement and sales generate significant benefits for all agents. Suppliers earn revenues of Rp 765 million to Rp 22 million (US $90,000 to $2600), excluding fixed costs, depreciation, extra-legal fees and non-payment. An estimated 22,500 farmers are involved in seed collection activities annually, earning Rp 795,000 to Rp 275,000 ($94 to $32), which equals 66-33% of their income during the 3-month seed collection season. Seed processing is also a lucrative activity for farmers living near seed companies, providing Rp 525,000 to Rp 330,000 per employee per dry-season. The prominent role of Wonogiri-Ponorogo seed suppliers in the national tree seed supply system is likely to remain, as the government agencies responsible for land rehabilitation program have established linkages with these suppliers and the species required match those available. Other regions of the country do not possess the advantageous geographic location or expansive forests of appropriate species to serve as the major source of tree seed for the country. However there is potential for provincial level seed suppliers to assume a large role in supplying tree seed to local customers – local government offices, locally based projects and NGOs/farmer groups.

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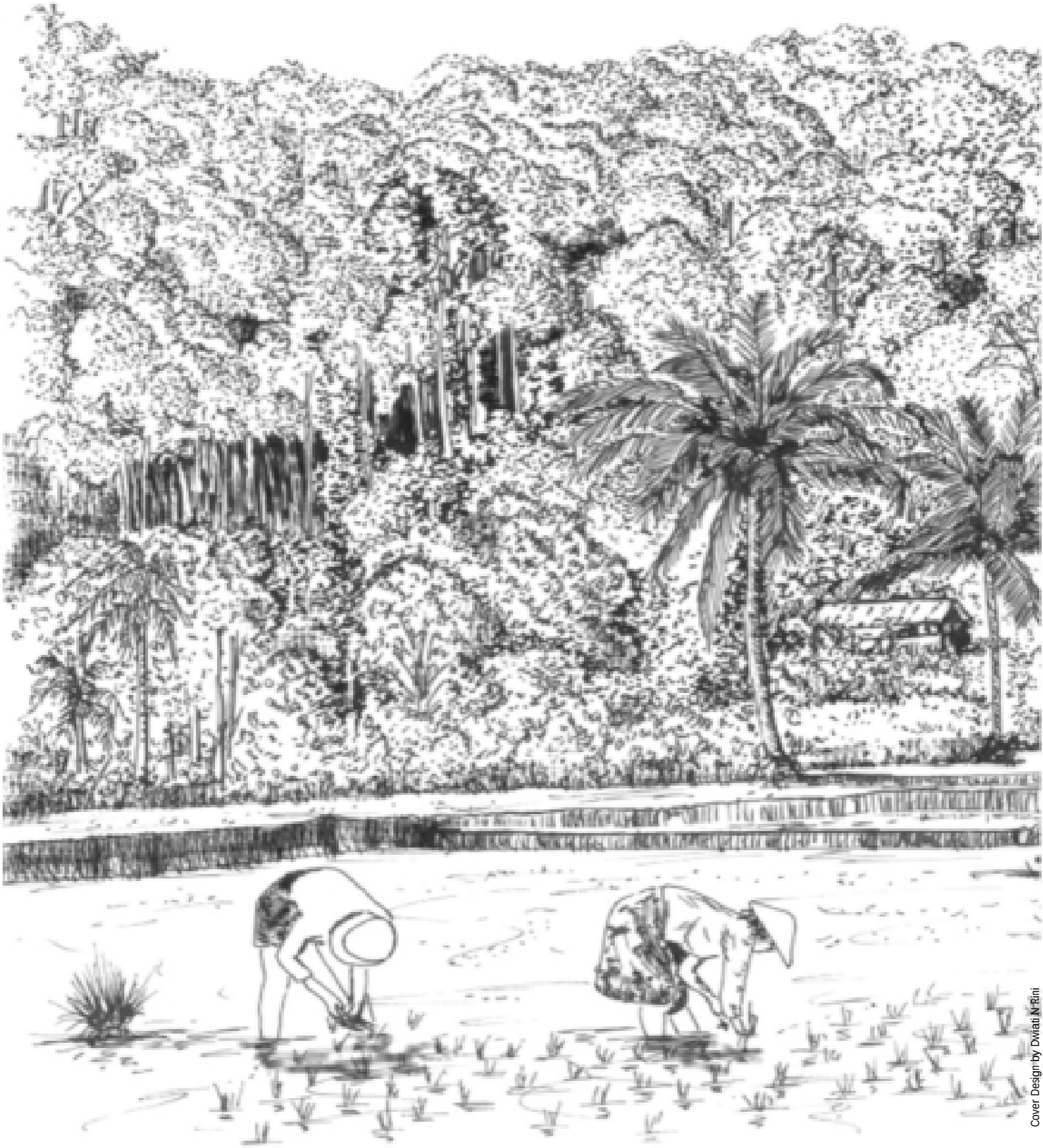

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