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STAND STRUCTURE OF PRIVATE SMALLHOLDER FOREST AS A REFLECTION OF LIVELIHOOD STRATEGIES: A CASE STUDY OF SEMOYO VILLAGE, GUNUNGKIDUL REGENCY, INDONESIA

Tatik Suhartati[1,2*], Ris Hadi Purwanto[1], Agus Setyarso[2], and Sumardi[1]

[1]Faculty of Forestry, Gadjah Mada University, Jl. Agro, No 1, Yogyakarta 55281, Indonesia.
E-mails: violethaty@gmail.com[*], risuhadi@yahoo.com, sumardibdh@yahoo.com
[2]Faculty of Forestry, Stiper Agricultural University, Yogyakarta, Indonesia.
E-mail: agusse@yahoo.com

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Abstract

The private smallholder forest significantly contributes to the wood industry as well as to the livelihood and needs of the society. Farmers grow mixtures of crops and species leading to a multi-layer vegetation covers, and forest stand. However, the structure and composition of the forest exposes a unique mosaic on the landscape. Therefore, the purpose of this study is to determine the association between forest stand structure and composition with varying farmer's livelihood strategies such as fully-managed forest farmer, partly-managed forest farmer, and non-managed forest farmer. Data were obtained from Semoyo Village, Patuk District, Gunungkidul Regency from 72 plots representing two types of planting pattern, namely: trees along the border and mixed patterns. The negative exponential model was used to describe the forest structure model. The results showed that fully-managed forest farmers tend to have few trees with the smallest diameter at breast height, plant more multi-purposes trees species. All stand structures in the three types of farmers' can be described by a negative exponential model, but each type possessing a different rate of diminishing in the number of trees. All of these showed that differences in stand structure are a reflection of differences in livelihood strategies.

Key words: diameter distribution, farmers occupation, negative exponential, planting pattern.

Introduction

Private smallholder forest (PF) can provide contribution to reducing the deficit of wood demand is being faced by the forestry world. In Indonesia, the supply of raw materials from community forests increased from 4.8 million m^3 in 2015 to 6.2 million m^3 in 2018 (Nurmansyah 2019). As well as in Java island PF has grown rapidly over the years and has become the main source of raw materials for wood industries. The wide geographical distribution of PF has been influenced by government-initiated programs such as re-greening, land rehabilitation (watershed), and conservation. These programs generated self-sustained forests that have hugely benefited the communities. Therefore the development of PFs which also means developing the lives of PF farmers is important to study.

On the PF land, the farmers combine timber trees with agricultural crops (agroforestry) and applying the pattern of mixing various types of plants in a field (Amin and Mas'ud 2017). Trees are grown along the boundaries of fields and terraces in dryland systems or on hillsides (Sabastian el al. 2014). According to previous studies, diversification of crops even on small pieces of land affected both economic and ecological benefits (Regmi 2003, Zuazo and Pleguezuelo 2009, Atangana et al. 2014, Oktalina et al. 2016, Achmad and Diniyati 2018). Although communities practiced agroforestry in small pieces of lands, it still created opportunities for increasing crop production, as well as higher biodiversity (Grimble et al. 1994, Tilman et al. 2006, Clough et al. 2011).

Stand structures and compositions are influenced by farmer's orientation in forest establishment/management. According to Sanudin and Fauziyah (2015), the structures and compositions of monoculture forests optimize product uniformity which was a characteristic of commercial-oriented farmers, while subsistence farmers tend to cultivate mixed crops. Triwiyanto et al. (2015) stated that agroforestry practiced on dry land at Bulu, Kulon Progo showed mixed patterns and proximity models of uneven-aged forest stands.

Agroforestry systems include not only a form of forest dominated by 'cultivated trees', but also an anthropogenic vegetation formation derived from previous agricultural farming practices (Rahman et al. 2016). The old tradition of private ownership with smallholder social structure was the main reason for the variability in stand structure and species assemblage (Wulf and Klok 2014). The numerous benefits of PF have been triggered by structures and composition which were affected by the livelihood strategy (Peyre et al. 2006, Wulandari et al. 2014).

Farmers' livelihood strategies are reflected in their main types of occupation. Farmers' livelihoods can be grouped into full-time farmers, part-time farmers, and not working in agriculture (non-farmers) (Guillerme et al. 2011, Liu et al. 2018, Dhehibi et al. 2020). Previous research on community forest structure was found associated with altitude (Talaohu 2012), land area (Triwiyanto et al. 2015), whereas concerning farmer livelihood strategy was not found. The purpose of this study is to determine the association between the PF stand structure with farmers' livelihood strategies.

Materials and Methods

Study area

This study was conducted at Semoyo Village, Patuk District, Gunungkidul Regency, Special Region of Yogyakarta Province, Indonesia. The village is geographically located at 7°51′0.61" – 7°53′25.45" S and 110°28′3.17" – 110°29′30,66" E (Fig. 1). It was selected because from a Government document (2018), it was obtained that 90.77 % of the family heads are farmers who lean on land to fulfill their family needs.

Sampling methods, tools and measurement methods

The research data were obtained from 'Serikat Petani Pembaharu' (SPP) farmers' group including 262 members. This

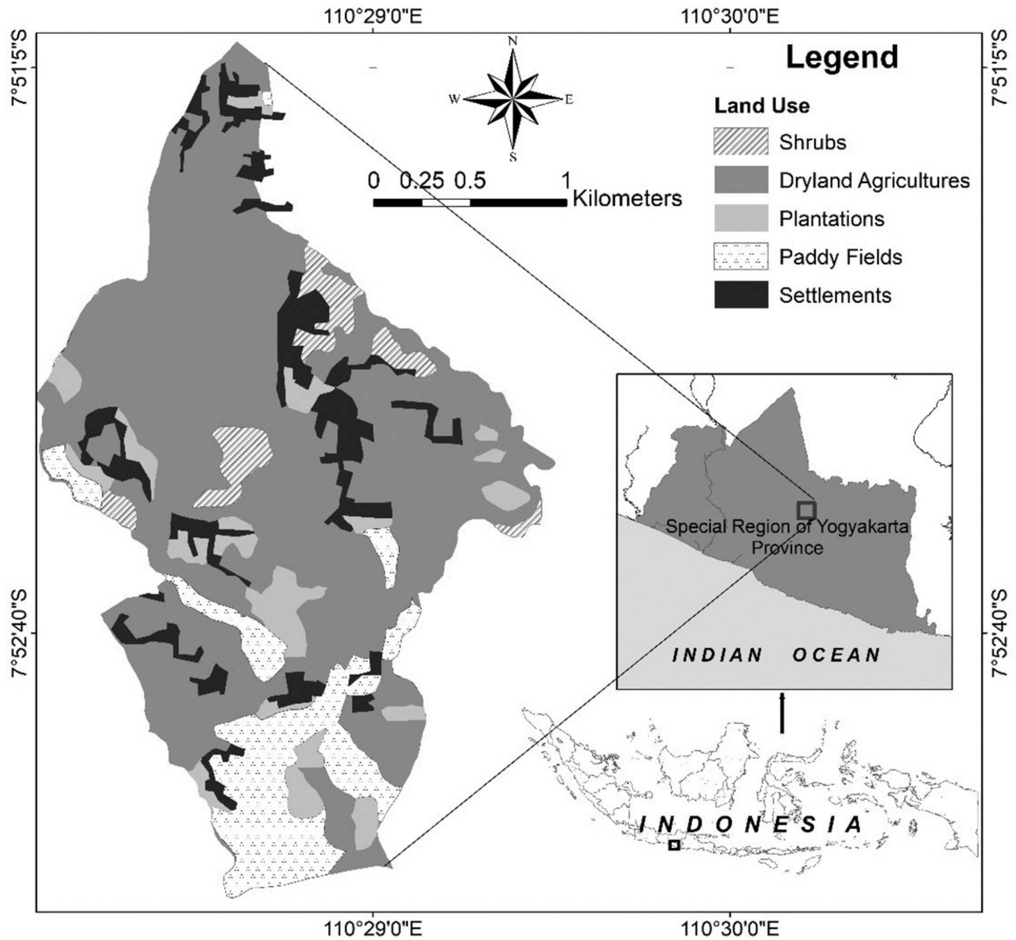

Fig. 1. Location of Semoyo Village.

study was conducted from February to December 2018. A total sample of 72 farmlands was selected based on the 27.5 % sampling intensity and an error limit tolerance of less than 10 % as stated by Israel (1992). Samples were selected by using purposive sampling method based on the type of occupation, namely 38 fully-managed forest farmers, 29 partly-managed forest farmers, and 5 non-managed forest farmers.

Observations were carried out to obtain distinct categories of forest stands and community livelihoods. Furthermore, parcels of lands were classified based on planting patterns, i.e. trees along the border (TAB), and mixed planting. There were observed 23 (33 %) samples of TAB patterns and 49 (67 %) samples of mixed patterns. Diameter at breast height (DBH) of five species of timber forest product (TFP) trees commonly found at the research sites was measured using a diameter tape. The commonly cultivated species for timber are Java teak (*Tectona grandis* L.f.), Big-leaf mahogany (*Swietenia mac-*

rophylla King), Indian rosewood (*Dalbergia latifolia* Roxb.), Batay (*Paraserianthes falcataria* (L.) Nielsen), and Australian wattle (*Acacia auriculiformis* A. Cunn. ex Benth). The measurement of TFP with a diameter of 5 cm and above, the various types and number of multi-purposes trees species (MPTS) trees were all recorded without diameter measurements. The area of land was also measured with a GPS Garmin ETREX 30x. Additionally, respondents were interviewed to ascertain the socio-economic conditions and land management practices executed in the community.

Data analysis

Data were analyzed to obtain PF stand structure in the form of tree diameter distribution which was a reflection of farmers' livelihood strategies in practicing the two types of planting patterns. Ziegenspeck (2004) divided the lifestyle of farmers into full-time, spare-time, and non-farmers. This research separates farmers into three type's occupation as reflected their livelihood strategies, namely:

1) Fully-managed forest farmers. They are farmers who do not have other occupations and depend on land-based activities to meet their needs.

2) Partly-managed forest farmers. They have other occupations such as construction or factory workers. However, income generated from land-based activities does not meet their cost of living so they spend their spare time working in other places. Therefore they depend on other sources for income.

3) Non-managed forest farmers. These are farmers with permanent occupations such as government employees, teachers. They tend to fulfill their needs without depending on land-based activities. However, they have very little leisure time to manage their forest.

The stand structure represented by the diameter distribution in the two planting patterns practiced by different types of farmers was analyzed. Triwiyanto et al. (2015) found that the diameter distribution model in PF can be described in a negative exponential model. All analyses were carried out by developing a tree diameter distribution model using the negative exponential equation (1) as stated by Meyer (1952).

$$N_i = K \cdot e^{-\alpha \cdot DBH_i}, \quad (1)$$

where: N_i and DBH_i are number of stems and midpoint of the *i*-th diameter class, respectively; α and K are the parameters of the distribution; e = 2.7183. The parameter α determines the rate at which trees diminish in successive diameter classes, while K indicates the relative density of the stand.

Results

Generally, most farmers in Semoyo Village own 2 parcels of land, dominated by landholding area less than 0.5 ha on fully-managed forest farmer and partly-managed forest farmer (Table 1).

The farmers practiced agroforestry by managing drylands to plant crops, fruit-trees, timber-trees, and MPTS. However, it was discovered that PF is the major source of livelihood. Variation in species composition showed that the combination dominated by timber forest product (TFP), non-timber forest product (NTFP), fruits product (FrP), and food crops (FC) (Table 2). There were 5 kinds of TFP species, 12 NTFP, 11 FrP, 3 FC, and 2 HnS (herbs and spices) (Table 3).

Table 1. Land characteristic.

Land Characteristic	Interval	Percentage, %		
		Fully-managed forest farmer	**Partly-managed forest farmer**	**Non-managed forest farmer**
Landholding area, ha	<0.5	52.6	58.6	40.0
	0.5-1	26.3	27.6	0.0
	>1	21.1	13.8	60.0
Number of land parcels	1	10.5	13.8	0.0
	2	36.9	34.5	60.0
	3	52.6	51.7	40.0

Table 2. Variation of species composition.

No	Species composition	Number of species	Number of respondents
1	TFP+NTFP + FC	2 to 4 TFP + 1 to 2 NTFP + 1 FC	2
2	TFP+ NTFP+FrP + FC	2 to 5 TFP + 1 to 5 NTFP+ 1 to 6 FrP + 1 to 2 FC	44
3	TFP+NTFP+FrP+F-C+HnS	2 to 5 TFP + 0 to 4 NTFP+ 2 to 7 FrP + 1 to 2 FC + 1-2 HnS	21
4	TFP+NTFP+FrP+F-C+HnS+Veg	2 to 5 TFP + 1 to 2 NTFP+ 2 to 5 FrP + 1 FC + 1 HnS + 1 Veg	2
5	TFP+NTFP+FrP+F-C+HnS+Veg+F	2 to 4 TFP + 1 to 2 NTFP+ 2 to 5 FrP + 1 to 2 FC + 1 HnS + 1 to 3 Veg+ F	3

Note: TFP – timber forest product; NTFP – non timber forest product; FrP – fruits product; FC – food crops; HnS – herbs and spices; Veg : vegetable; F – forage.

Table 3. Types of plants.

No	Group	Local name	English name	Latin name
1	TFP	Mahoni	Big-leaf mahogany	Swietenia macrophyla King
		Jati	Java teak	*Tectona grandis* L.f.
		Sonokeling	Indian rosewood	*Dalbergia latifolia* Roxb.
		Akasia	Australian wattle	*Acacia auriculiformis* A. Cunn. ex Benth.
		Sengon	Batay	Paraserianthes falcataria (L.) Nielsen
2	NTFP	Kopi	Coffe tree	*Coffea robusta* Lindl. Ex De Willd
		Cengkeh	Clove	Syzygium aromaticum (L.) Meer. & Perry
		Cacao	Cacao tree	*Teobroma cacao* L.
		Petai	Bitter bean	Parkia speciosa Hassk.
		Jengkol	Dog-fruit	Archidendron pauciflorum Benth.
		Kemiri	Candlenut	*Aleurites moluccana* (L.) Willd.
		Asam	Tamarin	*Tamarindus indica* L.
		Randu	Ceiba	*Ceiba pentandra* Gaertn.
		Ketapang	Umbrella tree	*Terminalia catappa* L.
		Melinjo	Gnetum	*Gnetum gnemon* L.
		Gliriside	Gliricidia	*Gliricidia sepium* (Jacq.) Walp.
		Bambu	Bamboo	*Gigantocloa apus* Kurz.

No	Group	Local name	English name	Latin name
3	FrP	Kelapa	Coconut	Cocos nucifera L.
		Nangka	Jackfruit	Artocarpus heterophyllus Lamk.
		Sirsak	Soursop	Annona muricata L.
		Jambu mete	Chasew	*Anacardium occidentale* L.
		Mangga	Mango	Mangifera indica L.
		Rambutan	Rambutan	Nephelium lappaceum L.
		Durian	Durian	Durio zibethinus Murr.
		Alpukat	Avocado	Persea americana Mill.
		Pisang	Bananas	*Musa paradisiaca* L.
		Nanas	Pineapple	*Ananas comosus* (L.) Merr.
		Pepaya	Papaya	*Carica papaya* L.
4	FC/ additional staple food	Singkong	Casava	*Manihot esculenta* Crantz.
		Jagung	Corn	*Zea mays* L.
		Ketela rambat	Sweet potatoes	*Ipomea batata* L.
5	HnS	Laos	Galangal	*Alpinia galanga* (L.) Willd.
		Sereh	Lemongrass	*Cymbopogon citratus* L.
6	Vegetables	Cabai	Chili	*Capsicum frutescens* L.
		Terung	Eggplant	*Solanum melongena* L.

Table 4 showed that the fully-managed forest farmers planted more MPTS in the TAB pattern and the smallest percentage of mixed patterns. Mahogany and teak were the dominant species of TFP.

Table 4. Share of TFP and MPTS.

No	Species	TAB				Mixed					
		Fully-managed forest farmer		Partly-managed forest farmer		Fully-managed forest farmer		Partly-managed forest farmer		Non-managed forest farmer	
		%	*N*, ha^{-1}	%	*N*, ha^{-1}	%	*N*, ha^{-1}	%	*N*, ha^{-1}	%	*N*, ha^{-1}
1	*Tectona grandis*	21.6	133	29.5	145	21.4	214	20.3	175	20.3	276
2	*Swietenia macrophylla*	37.5	231	29.0	142	44.0	441	43.3	373	61.1	829
3	*Dalbergia latifolia*	21.3	132	28.3	139	15.5	155	17.5	151	7.4	100
4	*Paraserianthes falcataria*	2.6	16	4.3	21	7.2	72	6.1	53	0.9	12
5	*Acacia auriculiformis*	0.7	4	1.0	5	2.1	21	1.5	13	0.2	3
6	MPTS	16.4	101	7.9	39	9.9	99	11.3	98	10.1	137

Note: *N* – number of trees.

All the negative exponential equations obtained a high squared *R* ($R^2 > 0.7$) value, therefore it was stated that the models were suitable for describing data. The reverse J-shaped curves drawn based on these equations are shown in figures 2 and 3. Fully-managed forest farmers have the highest rate of diminish in the number of trees owned and this is shown in the α values in Table 5 and figures 2 and 3. Furthermore, for diameters more than 10 cm, non-managed forest farmers have highest number of trees and biggest diameter compared to other types of farmers as shown in Table 6.

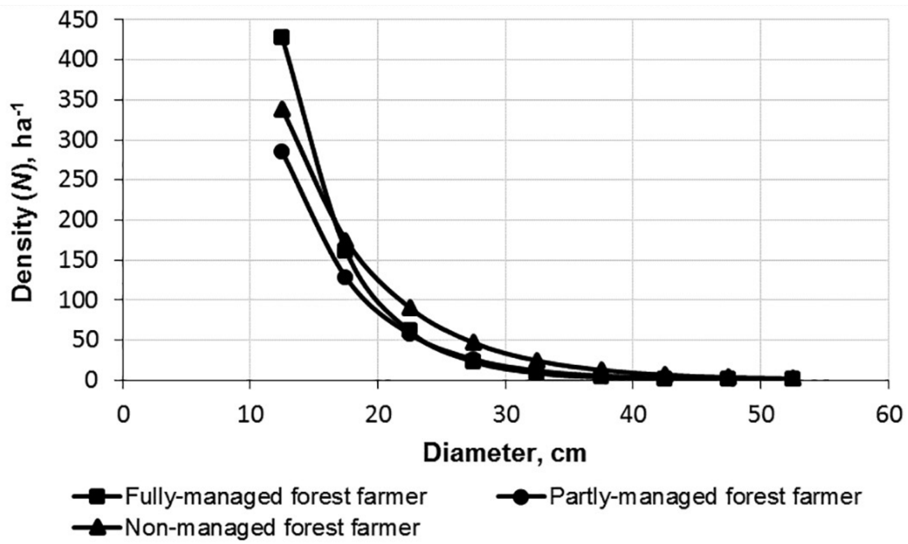

Fig. 2. Tree diameter distribution in mixed pattern.

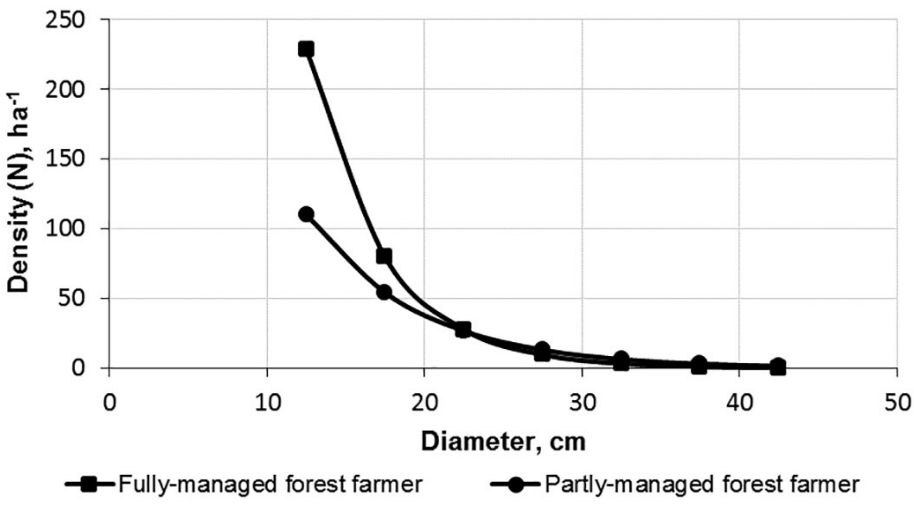

Fig. 3. Tree diameter distribution in TAB pattern.

Table 5. Negative exponential model for stand diameter distribution.

Agroforestry pattern	Types of farmers	Equation	Square *R*
TAB	Fully-managed forest farmer	N_i=3,150,380*2.7128$^{-0.210DBHi}$	0.99
	Partly-managed forest farmer	N_i=641,080*2.7128$^{-0.141\ DBHi}$	0.78
Mixed	Fully-managed forest farmer	N_i=4890,987*2.7128$^{-0.195\ DBHi}$	0.86
	Partly-managed forest farmer	N_i=2108,219*2.7128$^{-0.160\ DBHi}$	0.99
	Non-managed forest farmer	N_i=1766.657*2.7128$^{-0.132\ DBHi}$	0.93

Note: *N* – number of trees; *DBH* – diameter at breast height.

Table 6. Stand characteristic.

Main occupation	TAB				Mixed			
	***N*, ha^{-1}**		**DBH, cm**		***N*, ha^{-1}**		**DBH, cm**	
	Mean	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**
Fully-managed forest farmer	357	141.9	15.4	2.1	509	347.0	16.8	1.8
Partly-managed forest farmer	262	54.6	15.9	2.7	452	203.4	17.3	2.8
Non-managed forest farmer	-		-		812	464.5	17.6	1.1

Note: *N* – number of trees; Sd – standard deviation.

This model shows that non-managed forest farmers have the highest number of trees (184 ha^{-1}) with a mean diameter of 27.5 cm. However, partly-managed forest farmers have a higher number of trees and mean diameter in the two planting patterns as shown in Table 7, compared to fully-managed forest farmers. The number of trees with diameters more than 20 cm in TAB pattern owned by fully-managed forest farmers is 43 trees·ha^{-1} less than partly-managed forest farmers 52 trees·ha^{-1}.

Table 7. Number of trees more than 20 cm in diameter (based on model).

Types of farmer	TAB		Mixed	
	***N*, ha^{-1}**	**Mean of DBH, cm**	***N*, ha^{-1}**	**Mean of DBH, cm**
Fully-managed forest farmer	43	25.1	97	25.5
Partly-managed forest farmer	52	26.6	104	26.4
Non-managed forest farmer	-	-	184	27.5

Note: *N* – number of trees.

Discussion

Composition of trees

Trees along border and mixed planting patterns were generally practiced with two to five species of TFP trees which were either combined with MPTS (trees that produce various products namely leaves, fruits, vegetables, firewood, timber, etc.). Meanwhile, Triwiyanto et al. (2015) stated that there were three models of cultivated land in Bulu namely mixed, MPTS dominant plants, and forest dominant models.

Farmers decided to cultivate food crops in most areas of land, while the trees were only planted at the boundary of the land to reduce the impact of tree shade factors. According to Iskandar et al. (2017), the plants were categorized into 6 main functions, namely additional staple food/ carbohydrate source, fruit, vegetable, spice, industry/commercial, and wood. However, in Semoyo Village, a vegetable was not common and was found only in some farms. Several types of NTFP and FrP were similar to the ones discovered in other regions of Java (Pratama et al. 2015).

Farmers in Semoyo depend on food crops such as cassava, corn, and sweet potatoes to fulfill their daily needs. The typical agroforestry pattern used to achieve this is the TAB. Farmers practice TAB pattern on land that has a relatively flat topography or good biophysical conditions, with the food crops cultivated in the middle of the farm and surrounded by trees. Farmers are faced two options either to fulfill their basic needs by cultivating crops or planting trees as stated by Soerianegara and Mansuri (1994).

These composition differences are likely due to differences in management, as written by McClellan et al. (2018). Farmers are knowledgeable of the value of on-farm tree diversity for the sustenance of their livelihood. This is in accordance with Regmi (2003), Oktalina (2016). Banana and coconut are types of FrP that are always planted by fully-managed forest and partly-managed forest farmers because they produce fruits throughout the season, thereby generating income throughout the season. The composition of these plants allows farmers to have continuous income even during different harvest periods of various plants, as stated by Herwanti et al. (2019). This was the economic gains a farmer received from the practice of agroforestry (El-Tantawi et al. 2017).

Generally, most farmers in Semoyo Village own 2 parcels of land and these help in the selection of land allocation for planting patterns. Additionally, both fully-managed forest and partly-managed forest farmers own a variety of species while non-farmers cultivated less number of species. It was observed that fully-managed forest farmers prefer to plant food crops than trees. However, trees that produce fruits, TFP, and NTFP are planted at the boundary of the land and prevent soil erosion. Fully-managed forest farmers are characterized by optimal use of land because the farmers tend to cultivate crops and trees even though the land that is owned is narrow.

The farmers practiced agroforestry patterns after considering the biophysical conditions of the land (topography, soil fertility), landholding area, and availability of manpower because they aid the farming processes and socio-economic needs as found in Fujiwara et al. (2017) and Suhartati et al. (2018). Relatively fertile land with flat topography and availability of manpower, the farmers manage food crops using the TAB pattern, and in the absence of manpower, the mixed pattern becomes an option. Partly-managed forest farmers adopted mixed patterns because there was not enough time to cultivate the land. The wives of the farmers usually work on the farms, this is in line with the statement by Achmad and Diniyati (2018). Additionally, intensive tree planting is associated with increased off-farm incomes (Sabastian et al. 2014).

The farmers in Semoyo were interested in planting trees on their farms because of its land suitable, economic values, and the availability of good seedlings. Teak is suitable for environments that have existed since time immemorial and are costly while mahogany easily grows in the study area. Rosewood grows slowly, however, it has also been cultivated for a long time and is even costlier than teak. Australian wattle was introduced for land rehabilitation, while Batay was chosen because of its high demand by light wood industries. Teak, mahogany, and rosewood have a good seedling that regenerates naturally. Huxley (1999) stated that the choice of species is influenced by both the farmer's objectives and constraints. Meanwhile, the farmer's choice of tree species differs according socio-economic and environment factors (Goibov et al. 2012), social capital and networks, labour availability (Teklewold *et al.* 2013), inherited across generation (Salampessy et al. 2017) and land suitability, increment, availability of manpower, cost, and easy maintenance (Wijayanto 2011).

Fully-managed forest farmers have a higher percentage of MPTS in TAB patterns than partly-managed forest farmers. They tend to manage land and completely depend on land-based activities so they need to produce varieties of crops for sale. Furthermore, the planting of MPTS plays an important role in their basic income and they tend to cultivate more FrP and NTFP trees as medium-term commodities to satisfy their basic needs unlike partly-managed forest farmers and non-managed forest farmers. While non-managed forest farmers have the highest percentage of mahogany in the mixed pattern (61.1 %) as a result of the fact that they naturally regenerate faster than teak. Non-managed forest farmers do not cultivate and manage their lands, let the trees grow without maintenance.

Modeling in stand structure

Stand structures of forests were described by age, diameter distribution, and canopy classes. It was also observed by its density level which indicates its condition. Farmers usually do not remember the ages of certain trees, because they were not planted simultaneously on one land, making it difficult to detect. These types of PF were uneven-age stand. In an uneven-aged stand, the frequency distribution of the trees is based on its diameter and these lead to a reverse J-shaped curve (Daniel et al. 1979). Reverse J-shaped curve in the negative exponential model was also found in PF (Triwiyanto et al. 2015). The diameter distribution of trees resembles a reverse J-shaped curve and this indicates an uneven-aged structure, therefore tree density decreases with an increasing diameter (Daniel et al. 1979, Tavankar 2015).

In this research, stand structures were showed by the diameter distributions of five TFP trees, well modeled by the negative exponential. The number of trees in various diameter classes per hectare is one of the parameters that indicates stand performance. The performance showed that farmers have trees for the next harvesting. Referring to uneven-aged forests, this condition is said in a balanced condition (Pamoengkas and Zamzam 2017, Pamoengkas et al. 2018).

Farmers in the various occupational categories have different rates of diminishing in the number of trees at the two planting patterns. Fully-managed forest farmers have the highest rate of diminishing than other farmers in both planting patterns. Furthermore, the average non-managed forest farmer's diameter of trees was higher than the other main occupations. Fully-managed forest farmers sell and cut trees more often than partly-managed forest farmers and non-managed forest farmers. When social needs (ceremonial expenses, marriage ceremonies) have the highest frequency, therefore a large number of cash resources was needed. The increase in social needed, generally fulfilled by selling many cattle (hen or cock), and when this is not sufficient, the farmers sell trees to obtain cash, in line with Dhubháin et al. (2010). The diameter distributions of trees tend to differ due to planting pattern and types of farmer.

Stand structure and livelihood strategies

The PF stand structure is the result of planting, maintaining, and cutting. Tree planting activities are part of livelihood strategies to meet their needs. It was observed that PF cannot be separated from livelihoods. PFs were built because farmers need wood and a variety of products which serve as a livelihood strategy. Ellis (2000) states that farmers' livelihood strategies aim to maximize the benefits derived from land, trees, labour, cash, and other constraints, and at the same time, reduce critical risk factors. Meanwhile, Reed et al. (2017) state that integrating trees on agricultural land provides additional sources of income and greater resilience strategies to adapt to market or climate shocks.

The number of trees in each diameter class is an indicator of stand growth. Stand growth is a result of ingrowth, mortality, cutting (Davis and Johnson (1987) and upgrowth (Lei et al. 2006). Upgrowth is triggered and controlled by the maintenance of trees. In the case of PF in Semoyo Village, upgrowth was not triggered because there was no specific treatment for trees like fertilizers (on average is once per year), this was confirmed by Hani et al. (2016), or weeding. However, ingrowth was triggered by planting or enrichment of the farms where all the farmers get approximately 95 % of a seedling from their lands (natural seedling). In the two planting patterns, farmers do not have to cultivate crops regularly or even space it. The number of trees planted was not remembered. Furthermore, the mortality rate was one variable that was difficult to analyze because it was rare. Therefore, the most predictable variable that tends to influence the structure of PF forests is cutting.

Cutting was conducted by combining the cutting needs and selective cutting systems. The cutting needs system was practiced whenever farmers needed cash while the selective cutting system was particularly practised for house renovation and it was carried out by choosing trees that have large diameters and are quite old. However, both types of cutting systems are implemented by all of the respondents. This indicates that the PF is savings for immediate or emergency needs as stated in a research conducted by Pratama et al. (2015).

The cutting intensity was discovered to be consistent with the need for cash. The number and volume were adjusted according to the need. Furthermore, tree cutting is also carried out by fully-managed forest farmers that solely depend on land-based activities for income whenever cash was needed to purchase agriculture production facilities, especially fertilizers for paddy fields. According to Soraya (2017), cutting intensity tends to influence the structure of PF because the average diameter of the remaining trees is generally smaller since the fact that those with larger diameters are hugely accepted in the market. Most trees sold usually have a diameter more than 20 cm.

Partly-managed forest farmers have more trees (more than 20 cm in diameter) compared with fully-managed forest farmers because they satisfy some of their needs by working as labourers. Anonymous (2007) stated that reduction of rural poverty among small farm households includes increasing opportunities for off-farm work alongside ongoing efforts to improve agricultural productivity while Regmi (2003) discovered that changes in livelihood priorities and opportunities encouraged households to plant more trees on farms. Generally, fully-managed forest farmers tend to have the least number of trees and DBH unlike the partly-managed forest farmers and non-managed forest farmers.

The availability of farming manpower resources is a limiting factor in determining forest structure, especially for partly-managed forest farmers. Family members of farmers that engage in off-farm income-generating activities tend to limit the available manpower for agricultural purposes and this makes the planting of trees to be easier for them because it requires comparatively less manpower input. Furthermore, the rapid growth of off-farm employment in Semoyo Village creates a great challenge for the younger generations that seem not to be interested in working as farmers. This was in line with Vanwey and Vithayathil (2013) and Zhu et al. (2019).

Conclusion

Our findings indicate that there were differences in the stand structure and composition of the three types of farmers. The stand structure characterized by differences in the percentage of MPTS, number of trees (*N*, ha^{-1}), the average diameter and rate of diminishing in number of trees shows that stand structure is a reflection of different livelihood strategies in the fully-managed forest, partly-managed forest, and non-managed forest farmers.

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