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Economic analysis of groundnut (*Arachis hypogaea*) and soybean (*Glycine max*) as intercropping plants in two agroforestry systems

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Abstract. *Karmini, Sarminah S, Karyati. 2017. Economic analysis of groundnut (*Arachis hypogaea*) and soybean (*Glycine max*) as intercropping plants in two agroforestry systems. Biodiversitas 18: 483-493.* An agroforestry is a farming system combining forestry plant and agricultural plant. Two agroforestry systems of sengon (*Falcataria moluccana*)-groundnut (*Arachis hypogaea*) and jabon (*Anthocephalus cadamba)*-soybean (*Glycine max*) have been done and are proven to be successful. The objective of this study was to analyze the application of *A. hypogaea* and *G. max* as intercropping plants in two agroforestry systems from the aspect of economy. The study was conducted from January to June 2016 in Education Forest, Forestry Faculty, Universitas Mulawarman, Samarinda City, East Kalimantan Province, Indonesia. Data analysis was done to calculate the cost, revenue, and profit of the application of *A. hypogaea* and *G. max* as intercropping plants in two agroforestry systems. The results indicate that two agroforestry systems of *F. moluccana-A. hypogaea* and *A. cadamba-G. max* are feasible and applicable to rehabilitate the critical lands. The application of *A. hypogaea* as an intercropping plant in the agroforestry system of *F. moluccana* and *A. hypogaea* expended total cost as much as Rp. 10,985,000.00 ha^{-1} cs^{-1}, and it obtained total revenue as much as Rp. 14.000.000,00 ha^{-1} cs^{-1}, so it gave profit as much as Rp. 3,015,000.00 ha^{-1} cs^{-1}. An agroforestry system of *F. moluccana* and *A. hypogaea* gives many benefits from the aspect of economy, social, ecology, and conservation. Total cost, total revenue, and profit of the application of *G. max* as an intercropping plant in the agroforestry system of *A. cadamba* and *G. max*, in the first year in the first cropping season, were Rp. 11,019,000.00 ha^{-1} cs^{-1}; Rp. 3,500,000.00 ha^{-1} cs^{-1}; and Rp. 7,519,000.00 ha^{-1} cs^{-1}, respectively. Although *G. max* farm was not profitable to do in some critical lands, the agroforestry system of *A. cadamba* and *G. max* gave many benefits from the aspect of ecology and conservation.

Keywords: Agroforestry, *Arachis hypogaea,* economic analysis, *Glycine max*

INTRODUCTION

Agroforestry is a system of farm activities which combines plant or other kinds of forestry plant with the agricultural plant. Agroforestry activity could be done at farm area, inside or outside of forest area. Agroforestry system could be applied to critical land or degraded land. According to Sudomo (2007), agroforestry is a model of community forest or social forestry which is expected to enable the increase of land productivity per wide area and, in future, it can increase community welfare. Besides, agroforestry is expected to have a positive function in land and water conservation, since it is applied mostly in degraded areas as an effort to rehabilitate the land.

Agroforestry system uses a combination of many kinds of forestry plants with agricultural plants. The tree raises positive effect on the supply of ground water for the intercrops that grow among trees. Besides, shelter gives buffer effect to anticipate the temperature fluctuation and extreme temperature of both ground temperature and atmosphere temperature of the land (Hamid 2008). Some previous researches chose sengon (*Falcataria moluccana* (Miq.) Barneby & J.W. Grimes) as forestry plant in agroforestry system, and combined it with other agricultural plants. The combination of sengon with other plants was as follows: sengon-nilam (Sudomo 2007), sengon-maize-chili-stick nut (Hamid 2008), sengon-coffee-cacao-gliricidia-maize-ginger-stick nut (Mindawati et al. 2013), groundnut-sengon-manglid (Swestiani and Purwaningsih 2013), sengon-paddy (Wahyudi and Panjaitan 2013), and sengon-groundnut (Widiyanto and Sudomo 2014).

Sudomo (2007) stated that most people like to cultivate *F. moluccana* because it was fast-growing and easy breeding, and its timber could be used to make many products such as furniture and firewood, and its leaf could be used as cattle provisions and as compost material. Moreover, *F. moluccana* and nilam are proven to have potential to be cultivated in agroforestry system at Sukamulih Village, Tasikmalaya District, Indonesia. Meanwhile, the study result of Wahyudi and Panjaitan (2013) indicated the superiority of agroforestry system that uses a combination of *F. moluccana* and upland paddy. That system becomes the best choice in the development of Industrial Plantation Forest, because it gives the best yield rate of *F. moluccana* and upland paddy, creates job opportunities, increases income of local community, grows own feeling on natural resources, creates positive perception to develop the plantation forest and agroforestry, guards the forest security, and decreases the degradation rate of forest. The fact in the field shows that most land is in critical and damage condition because of the continuous effort to fulfill the economic need. People have to contact with nature, so the activity to rehabilitate forest and its surrounding area has a potential conflict (Nasution 2010).

According to Sembiring et al. (2014), groundnut (*Arachis hypogaea* L.) is a food commodity that has high economic value. *A. hypogaea* has high nutrition ingredient especially protein and grease. *A. hypogaea* is mostly used as food-stuff and industrial material (Raja et al. 2013). Researches on *A. hypogaea* farming have been done by some researchers such as Hidayat et al. (2004), Muklis et al. (2012), Raja et al. (2013), Riska (2014), Sembiring et al. (2014), and Boekoesoe and Saleh (2015).

Jabon (*Anthocephalus cadamba* (Roxb.) Miq.) is a tropical tree species that is native to South Asia and Southeast Asia, including Indonesia (Krisnawati et al. 2011a). *A. cadamba* is preferred by the local community because it is a fast-growing tree species and has good adaptability to drought and waterlogging stresses (Hadi et al. 2015; Seo et al. 2015; Sudrajat et al. 2015). *A. cadamba* is used in community forests and greening activities such as reforestation programs, afforestation programs, rehabilitation activities of waterlogged marginal sites, and replanting the marginal dryer sites. *A. cadamba* has wood for multiple ends uses such as plywood, light construction materials, flooring, beams and rafters, boxes and crates, tea-chests, packing cases, shuttering, ceiling boards, toys, wooden shoes, bobbins, yokes, carvings, matches, chopsticks, pencils, canoes, and inexpensive furniture. The pulp of *A. cadamba* for medium quality paper and the fresh leaves are used as cattle fodder or as plates and serviettes (Soerianegara and Lemmens 1993).

Soybean (*Glycine max* (L.) Merrill) is valued as a productive and adaptable crop which fits well into the cropping patterns of varying agro-climatic conditions (Amusat and Ademola 2013). For a long time, soybean has been a part of the traditional food for the human population which comes in various forms such as tofu, soy-milk, green vegetable soybeans, tempeh, and soybean oil, and also, in its second generation of soy-foods such as soy-nuts, alternatives cheese, and soymilk yogurt. According to Agroudy et al. (2011), the soy oil is one of the widest spread vegetable oils. It is used directly in food to prevent its consumers from having blood pressure and arteriosclerosis; moreover, seeds of soybean contain the highest number of vitamins that are essential for the body.

The establishment of two agroforestry systems using *F. moluccana* and *A. cadamba* as forestry plants and *A. hypogaea* and *G. max* as agricultural plants are important to apply because it has high economic potential. The aim of this study was to analyze the application of *A. hypogaea* and *G. max* as intercropping plants in two agroforestry systems from the aspect of the economy. The result of this study is expected to give information to businessman, government, stakeholders, and other researchers about cost expenditure, potential revenue, and profit estimation that could be obtained from the application of *A. hypogaea* and *G. max* as intercropping in the two agroforestry systems. That information are useful to determine the capital needed to start an agro-business. This study compared two agroforestry systems of *F. moluccana-A. hypogaea* and *A. cadamba-G. max* to offer the best agroforestry system that could be applied in the critical lands.

The sections of this study are organized in the following sequence. Materials and methods section explaining the study area, procedures, and data analysis. The next section presents the results and includes some discussions. The last section is the conclusion that summarizes findings and offers recommendations.

MATERIALS AND METHODS

Study area

This study was conducted for 6 months from January to June 2016. The experiment was done in Forest Education, Faculty of Forestry, Universitas Mulawarman, East Kalimantan, Indonesia. Experimental plots were located in Lempake, Samarinda City, East Kalimantan Province, Indonesia (Figure 1). There are many previous researches on agroforestry systems in some locations in Indonesia. Some of them did the research on *F. moluccana* in Tasikmalaya District, West Java Province (Sudomo 2007), in East Java Province (Hamid 2008; Mindawati et al. 2013), and in Ciamis District, West Java Province (Sudomo 2013; Swestiani and Purwaningsih 2013; Widiyanto and Sudomo 2014). The study on *A. hypogaea* had been done by some researchers in several provinces in Indonesia. Several *A. hypogaea* studies were located in West Java Province (Hidayat et al. 2004), in Purworejo District, Central Java Province (Muklis et al. 2012), in Medan City, North Sumatera Province (Raja et al. 2013), in Sigi District, Central Sulawesi Province (Riska 2014), in Deli Serdang District, North Sumatera Province (Sembiring et al. 2014), and in West Gorontalo District, Gorontalo Province (Boekoesoe and Saleh 2015). However, the publication of researches about two agroforestry systems of *F. moluccana-A. hypogaea* and *A. cadamba-G. max* in East Kalimantan Province is still limited.

Procedures

Some researchers collected primary data through a survey to some farmers as respondents to reach their aims of the research. Siregar et al. (2007) surveyed 40 respondents to analyze the economic value of some agroforestry systems. Asnah and Natal (2009) surveyed 45 respondents to calculate the profit of *A. hypogaea* farm. Another researcher, Muklis et al. (2012), surveyed 26 respondents to analyze the profit of *A. hypogaea* farm. Amusat and Ademola (2013) collected primary data using interview schedules from the 130 selected *G. max* farmers, but only 123 of the schedules were found to be useable. Dogbe et al. (2013) determined 140 *G. max* farmers as enumerators for their study. In addition, Riska (2014) surveyed 30 respondents to analyze the production and profit of *A. hypogaea* farm. Zoundji et al. (2015) selected 324 soybean producers as respondents.

This study was different from those studies above in which primary data for the analysis of economy were collected from on-farm experimental plot established to study two agroforestry systems of *F. moluccana*-*A. hypogaea* and *A. cadamba*-*G. max*. Experimental researches related to agroforestry had been done by some researchers with different kinds of plant combination. For example, tree-maize (Bertomeu 2006), sengon-nilam (Sudomo 2007), sengon-maize-chili-stick nut (Hamid 2008), sengon-coffee-cacao-gliricidia-maize-ginger-stick nut (Mindawati et al. 2013), groundnut-manglid (Sudomo 2013), groundnut-sengon-manglid (Swestiani and Purwaningsih 2013), sengon-paddy (Wahyudi and Panjaitan 2013), and sengon-groundnut (Widiyanto and Sudomo 2014).

In this study, experimental plot (Figure 2) of *F. moluccana* and *A. hypogaea* had a size of 10 m × 10 m per plot with two replications or as many as two plots. Similar to *F. moluccana* and *A. hypogaea*, an experimental plot of *A. cadamba* and *G. max* had the same of size and replication. *F. moluccana* and *A. cadamba* were cultivated with a distance of 3 m × 3 m. *A. hypogaea* crops were cultivated among *F. moluccana* trees as intercropping with a size of 20 cm x 20 cm. *G. max* crops were also cultivated among *A. cadamba* trees as intercropping with size of 20 cm x 20 cm. The cultivation activities included land preparation, planting, crop maintenance (weeding, fertilizing, and control of pests and diseases), and harvesting. Harvesting activity was only done to gather *A. hypogaea* and *G. max* yields, but no timber harvesting of *F. moluccana* and *A. cadamba* trees.

Data analysis

This study was different from the previous study by Bertomeu (2006) which also made an experimental plot to collect primary data. Bertomeu (2006) collected primary data to study the financial evaluation of agroforestry systems of tree and maize. However, this study collected primary data to analyze the application of *A. hypogaea* and *G. max* as intercropping in two agroforestry systems from the aspect of the economy. In this study, data were analyzed to calculate the cost, revenue, and profit from the application of *A. hypogaea* and *G. max* as intercropping in two agroforestry systems. Cost is calculated from price and quantity of inputs. Thus revenue is the price of production yield, and meanwhile, profit is revenue minus cost (Slavin 2009). Besides primary data, this study also collected secondary data from the results of previous studies.

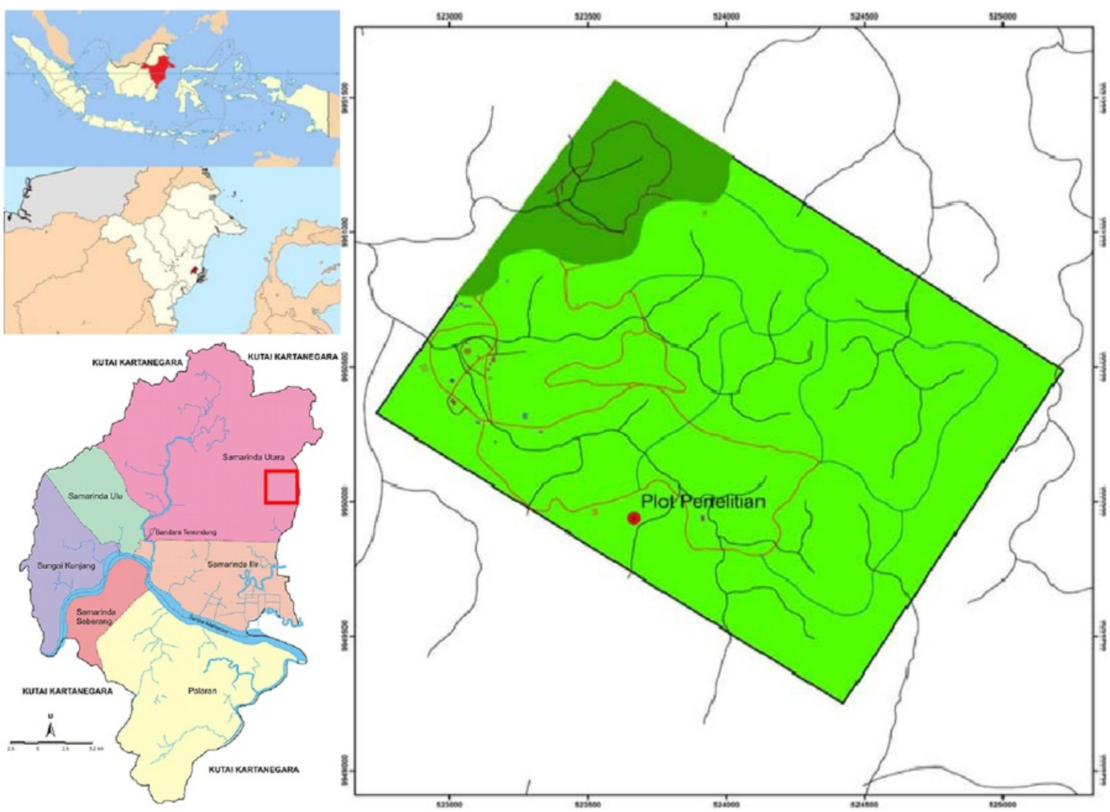

Figure 1. Study location in Forest Education, Faculty of Forestry, Universitas Mulawarman, East Kalimantan, Indonesia

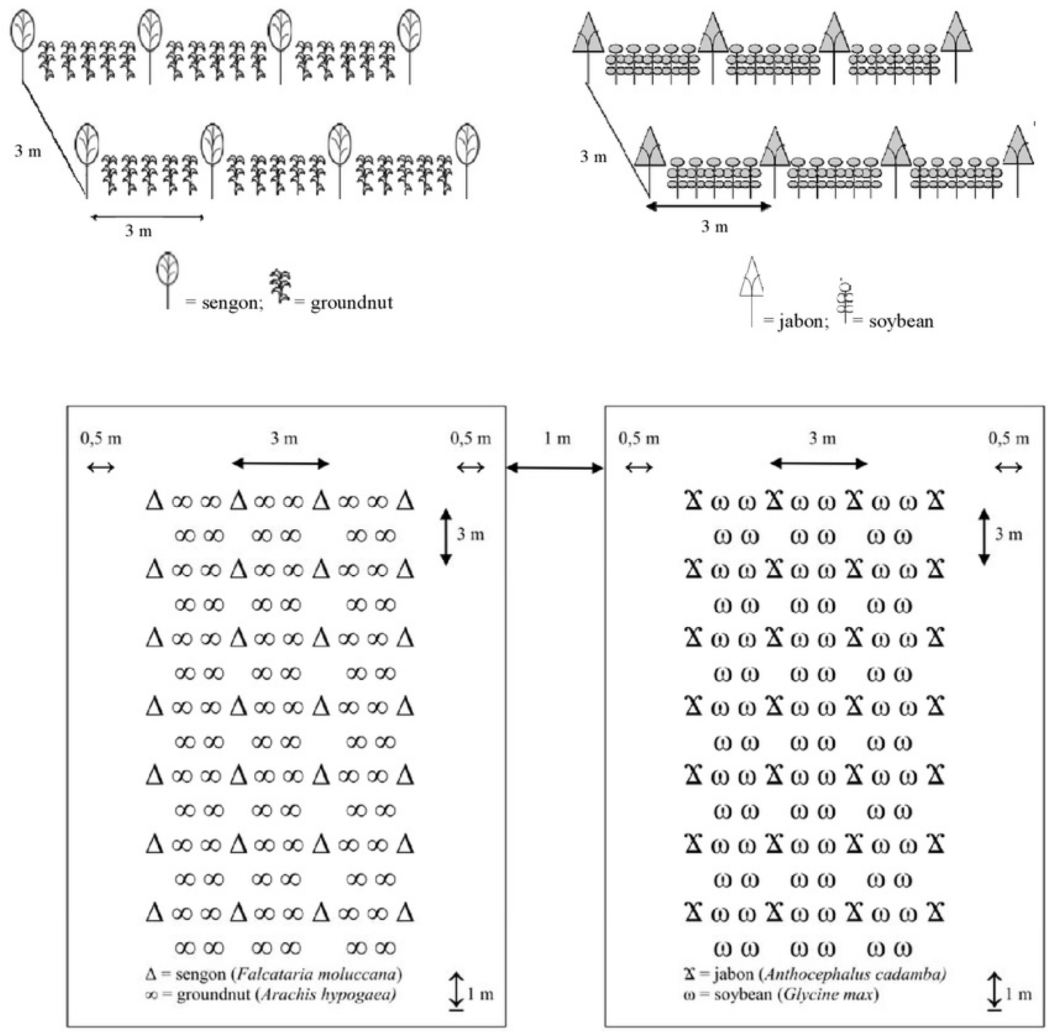

Figure 2. Layout of experimental plots in two agroforestry systems of *Falcataria moluccana-Arachis hypogaea* and *Anthocephalus cadamba-Glycine max*

RESULTS AND DISCUSSION

The application of an agroforestry system needs the cost expenditure to buy materials, depreciation of equipment, and wage of labor. Besides cost expenditure, the application of an agroforestry system gives revenue and profit. Table 1 shows economic analysis of *A. hypogaea* as an intercropping plant in an agroforestry system of *F. moluccana* (Figure 3.A) and *A. hypogaea* (Figure 3.B) during four months in East Kalimantan in the 2016 cropping season. Meanwhile, economic analysis of *G. max* as an intercropping plant in an agroforestry system of *A. cadamba* (Figure 3.C) and *G. max* (Figure 3.D) during four months in East Kalimantan in the 2016 cropping season is presented in Table 2.

Material cost was expended on buying *F. moluccana* seedling, *A. hypogaea* seed, *A. cadamba* seedling, *G. max* seed, NPK fertilizer, pesticide, plastic strings, and gunny sack. Fertilizer is given to increase soil fertility. Material cost for the application of an agroforestry system of *A. cadamba* and *G. max* (Rp. 7,754,000.00 ha^{-1} cs^{-1}) was bigger than that of *F. moluccana* and *A. hypogaea* (Rp. 7,720,000.00 ha^{-1} cs^{-1}). Material cost differed between the application of an agroforestry system of *F. moluccana-A. hypogaea* and *A. cadamba-G. max* because of some reasons. The price of *A. cadamba* seedling was more expensive than that of *F. moluccana* seedling, however, the price of *A. hypogaea* seed was more expensive than that of *G. max*. That two agroforestry systems need gunny sack in different number depends on its yield.

Table 1. Economic analysis of *Arachis hypogaea* as intercropping in an agroforestry system of *Falcataria moluccana* and *Arachis hypogaea* during four months in East Kalimantan in the 2016 cropping season

No.	Cost	Quantity		Price			Total (Rp. ha^{-1} cs^{-1})
Production cost							
Material cost							
1.	*F. moluccana* seedling	800.00	units ha^{-1}	Rp.	3,000.00	unit^{-1}	2,400,000.00
2.	*A. hypogaea* seed	150.00	kg ha^{-1} cs^{-1}	Rp.	20,000.00	kg^{-1}	3,000,000.00
3.	NPK fertilizer	100.00	kg ha^{-1} cs^{-1}	Rp.	15,000.00	kg^{-1}	1,500,000.00
4.	Pesticide	25.00	kg ha^{-1} cs^{-1}	Rp.	30,000.00	kg^{-1}	750,000.00
5.	Plastic strings	1.00	unit ha^{-1} cs^{-1}	Rp.	30,000.00	unit^{-1}	30,000.00
6.	Gunny sack	20.00	units ha^{-1} cs^{-1}	Rp.	2,000.00	unit^{-1}	40,000.00
	Subtotal						7,720,000.00
Depreciation cost							
7.	Hoe	2.00	units ha^{-1}	Rp.	125,000.00	unit^{-1}	20,833.33
8.	Chopper	2.00	units ha^{-1}	Rp.	100,000.00	unit^{-1}	16,666.67
9.	Sickle	2.00	units ha^{-1}	Rp.	60,000.00	unit^{-1}	10,000.00
10.	Sprayer	1.00	unit ha^{-1}	Rp.	350,000.00	unit^{-1}	17,500.00
	Subtotal						65,000.00
Labor cost							
11.	Land preparation	7.00	days ha^{-1} cs^{-1}	Rp.	100,000.00	day^{-1}	700,000.00
12.	Planting	6.00	days ha^{-1} cs^{-1}	Rp.	100,000.00	day^{-1}	600,000.00
13.	Crop maintenance:						
	a. Fertilizing	4.00	days ha^{-1} cs^{-1}	Rp.	100,000.00	day^{-1}	400,000.00
	b. Weeding	5.00	days ha^{-1} cs^{-1}	Rp.	100,000.00	day^{-1}	500,000.00
	c. Pests and diseases controlling	4.00	days ha^{-1} cs^{-1}	Rp.	100,000.00	day^{-1}	400,000.00
14.	Harvesting	6.00	days ha^{-1} cs^{-1}	Rp.	100,000.00	day^{-1}	600,000.00
	Subtotal						3,200,000.00
Total cost							10,985,000.00
Total revenue							
	A. hypogaea yield	1,000.00	kg ha^{-1}	Rp.	14,000.00	kg^{-1}	14,000,000.00
Profit							3,015,000.00

Table 2. Economic analysis of *Glycine max* as intercropping in an agroforestry system of *Anthocephalus cadamba* and *Glycine max* during four months in East Kalimantan in the 2016 cropping season

No.	Cost	Quantity		Price			Total (Rp. ha^{-1} cs^{-1})
Production cost							
Material cost							
1.	*A. cadamba* seedling	800.00	units ha^{-1}	Rp.	4,000.00	unit^{-1}	3,200,000.00
2.	*G. max* seed	150.00	kg ha^{-1} cs^{-1}	Rp.	15,000.00	kg^{-1}	2,250,000.00
3.	NPK fertilizer	100.00	kg ha^{-1} cs^{-1}	Rp.	15,000.00	kg^{-1}	1,500,000.00
4.	Pesticide	25.00	kg ha^{-1} cs^{-1}	Rp.	30,000.00	kg^{-1}	750,000.00
5.	Plastic strings	1.00	unit ha^{-1} cs^{-1}	Rp.	30,000.00	unit^{-1}	30,000.00
6.	Gunny sack	12.00	units ha^{-1} cs^{-1}	Rp.	2,000.00	unit^{-1}	24,000.00
	Subtotal						7,754,000.00
Depreciation cost							
7.	Hoe	2.00	units ha^{-1}	Rp.	125,000.00	unit^{-1}	20,833.33
8.	Chopper	2.00	units ha^{-1}	Rp.	100,000.00	unit^{-1}	16,666.67
9.	Sickle	2.00	units ha^{-1}	Rp.	60,000.00	unit^{-1}	10,000.00
10.	Sprayer	1.00	unit ha^{-1}	Rp.	350,000.00	unit^{-1}	17,500.00
	Subtotal						65,000.00
Labor cost							
11.	Land preparation	7.00	days ha^{-1} cs^{-1}	Rp.	100,000.00	day^{-1}	700,000.00
12.	Planting	6.00	days ha^{-1} cs^{-1}	Rp.	100,000.00	day^{-1}	600,000.00
13.	Crop maintenance:						
	a. Fertilizing	4.00	days ha^{-1} cs^{-1}	Rp.	100,000.00	day^{-1}	400,000.00
	b. Weeding	5.00	days ha^{-1} cs^{-1}	Rp.	100,000.00	day^{-1}	500,000.00
	c. Pests and diseases controlling	4.00	days ha^{-1} cs^{-1}	Rp.	100,000.00	day^{-1}	400,000.00
14.	Harvesting	6.00	days ha^{-1} cs^{-1}	Rp.	100,000.00	day^{-1}	600,000.00
	Subtotal						3,200,000.00
Total cost							11,019,000.00
Total revenue							
	G. max yield	500.00	kg ha^{-1}	Rp.	7.000.00	kg^{-1}	3,500,000.00
Profit							-7,519,000.00

Figure 3. A. *Falcataria moluccana*, B. *Arachis hypogaea,* C. *Anthocephalus cadamba,* and D. *Glycine max*

There was no difference between depreciation cost for the application of an agroforestry system of *F. moluccana-A. hypogaea* and that of *A. cadamba-G. max* because the kind, quantity, and price of equipment were same. There were many kinds of equipment needed to support farm activity. The equipment was hoe, chopper, sickle, and sprayer. The price of this equipment was different and it depended on the material and the quality of the equipment. Technical duration of an equipment is commonly three years. However, sprayer can be used for five years. Depreciation cost in the application of *A. hypogaea* and *G. max* as intercropping in two agroforestry systems was lower than material cost and labor cost.

The application of that two agroforestry systems expended labor cost in same numbers because those applications are done in the same critical land which has similar soil properties. Many kinds of activities are done in the application of two agroforestry systems of *F. moluccana-A. hypogaea* and that of *A. cadamba-G. max.* Those activities are land preparation, planting, crop maintenance, and harvesting. Land preparation expended more money than the planting activity. Activities of crop maintenance included fertilizing, weeding, and pests and diseases controlling. Weed control methods significantly affected *A. hypogaea* yield both on the Samnut 10 and MK 373 varieties (Olayinka and Etejere 2015). Crop maintenance needed more cost than harvesting activity because it involved more labor.

Total cost included material cost, depreciation cost, and labor cost. Total cost for the application of an agroforestry system of *F. moluccana* and *A. hypogaea* (Rp. 10,985,000.00 ha^{-1} cs^{-1}) was smaller than that of *A. cadamba* and *G. max* (Rp. 11,019,000.00 ha^{-1} cs^{-1}). Material cost was different between an agroforestry system of *F. moluccana-A. hypogaea* and that of *A. cadamba-G. max,* however, depreciation cost and labor cost were same.

In an agroforestry system of *F. moluccana* and *A. hypogaea*, there was no harvesting of *F. moluccana* yield in the first year because the aim of *F. moluccana* planting was to rehabilitate the critical lands. Crop maintenance of *F. moluccana* is done in the following years. There is a possibility that the harvesting activity is only to take the economic value of *F. moluccana* timbers. Farmers can obtain revenue from selling the *F. moluccana* timbers, so when there is no harvesting, it means no revenue. The economic potential of *F. moluccana* trees is very high from the aspect of tree growth level.

There were several prior researches measuring the growth level of diameter and height of *F. moluccana* in some plantation systems (Table 3). Sudomo (2007) investigated an agroforestry system of *F. moluccana* and nilam and found that the growth of *F. moluccana* on loamy sand soil is good enough. It was proven by the increasing of height and diameter at 18 months and 24 months. Meanwhile, two best agroforestry systems that could be applied widely in Blitar, East Java Province, are sengon-coffee-gliricidia-cassava-stick nut and sengon-coffee-cacao-gliricidia-ginger-stick nut because those systems gave the best sengon diameter growth (Mindawati et al. 2013). The result of a study by Swestiani and Purwaningsih (2013) and Wahyudi and Panjaitan (2013) showed that Mean Annual Increment (MAI) of *F. moluccana's* diameter in agroforestry system is wider than in monoculture system. The study by Krisnawati et al. (2011b) in smallholder plantations in Ciamis (West Java Province) recorded the mean diameter and height of *F. moluccana* trees which were younger than four years old, 5-10 years old, and 12 years old of stands. The wide variations in mean diameter and height are probably due to the difference in growing conditions including site quality, altitude, slope, and silvicultural management.

Arachis hypogaea mature at 90 and 95 days (Najiyati and Danarti 2000) or between 98 and 105 days (Olayinka and Etejere 2015). There were differences in *A. hypogaea* yield that obtained in monoculture system in some farm areas, as shown in Table 4. In United States of Amerika, *A. hypogaea* yield is higher than the average yield in tropical Africa. *A. hypogaea* yield of Macan variety in monoculture system is between 1,200 and 1,800 kg ha^{-1} (Najiyati and Danarti 2000). According to Asnah and Natal (2009), *A. hypogaea* farmers in Tagawiti Village, Ile Ape Subdistrict, Lembata District, who own land more than 0.5 ha have bigger profit than those who own land less than 0.5 ha.

There were differences in *A. hypogaea* yield in an agroforestry system in some locations. In this study, *A. hypogaea* as an intercropping plant in an agroforestry system of *F. moluccana* and *A. hypogaea* could produce yield as much as 1,000.00 kg ha^{-1}. The result of this study which was conducted in Forest Education, Forestry Faculty, Universitas Mulawarman, Lempake Subcity, Samarinda City, East Kalimantan Province was higher than the result of studies by Swestiani and Purwaningsih (2013) in Ciamis District, West Java Province and Widiyanto and Sudomo (2013) in Raksabaya Village, Cimaragas Subdistrict, Ciamis District, West Java Province. When the price of *A. hypogaea* yield was Rp. 14.000,00 kg^{-1}, the farmer could get potential revenue as much as Rp. 14,000,000.00 ha^{-1} cs^{-1}.

Sudomo (2013) reported that *A. hypogaea* yield decreases in an agroforestry system of *A. hypogaea* and manglid (19.63%) compared to *A. hypogaea* in a monoculture system. Similar to Sudomo's study (2013), Swestiani and Purwaningsih (2013), and Widiyanto and Sudomo (2014) also found that *A. hypogaea* yield in monoculture system was higher than that in an agroforestry system of *F. moluccana* and *A. hypogaea*. It was happened due to the shade of *F. moluccana* over *A. hypogaea* and the competition of *F. moluccana* with *A. hypogaea* in water and nutrition absorption (Widiyanto and Sudomo, 2014). According to Swestiani and Purwaningsih (2013), *F. moluccana*, manglid, and *A. hypogaea* will grow optimally when the environment factors (duration of sunshine, water, nutrition, CO_2, and growth space) are available adequately. The strategy to increase *A. hypogaea* yield is by increasing the area width for a more intensive farming and by expanding the planting area through the arrangement of planting pattern, the use of hybrid varieties, the use of appropriate machines and equipment, and the adequate supply of water (Department of Agriculture of Indonesia 2001).

Similar to an agroforestry system of *F. moluccana* and *A. hypogaea*, there was no harvesting of *A. cadamba* yield in the first year. However, crop maintenance is continued to be done to rehabilitate the critical lands in the following years. Reports by Sudarmo (1957) and Soerianegara and Lemmens (1993) showed an average diameter, a mean height, MAI, and wood production of *A. cadamba* (Tabel 5). The growth rates of both diameter and height of *A. cadamba* in Java are higher than those in South Kalimantan. The wide variations in mean diameter and height are probably due to differences in site quality and owners management practices (Krisnawati et al. 2011a).

The result of a study by Dogbe et al. (2013) showed monoculture system of *G. max* produces 509-642 kg ha^{-1} yield in Saboba and Chereponi Districts, Northern Region of Ghana. Meanwhile, Zoundji et al. (2015) found that 60.5%, 28.1%, and 11.4% of the soybean farmers in Benin had low (< 700 kg ha^{-1}), medium (between 700 and 1,000 kg ha^{-1}), and high (> 1,000 kg ha^{-1}) yield level, respectively (Table 6). The soybean grain yields obtained after harvest are inferior to 1,000 kg ha^{-1} for the majority of respondents. In this study, the application of *G. max* as an intercropping plant in an agroforestry system of *A. cadamba* and *G. max* could produce yield as much as 500.00 kg ha^{-1}. The selling price of *G. max* yield was Rp. 7,000.00 kg^{-1}, therefore the farmers owned revenue of Rp. 3,500,000.00 ha^{-1} cs^{-1} in the first cropping season. The revenue level is determined by yield quantity and selling price.

There are some factors influencing the level of *G. max* yields such as a characteristic of land, quality and quantity of inputs (material, equipment, and labor), cropping practice, climate condition, environment condition, and other factors. Dogbe et al. (2013) explained several factors could account for the low levels of productivity of *G. max* including poor soil health, pest, and diseases, unfavorable weather conditions, inadequate and untimely access to agro-inputs, equipment, and labor. According to Zoundji et al. (2015), yield level is significantly determined by gender issues. Technical factors such as the use of improved *G. max* varieties, the use of fertilizers, the plant density, and the practice of fallow in the cropping system have significantly and positively determined the level of yields. Constrains to soybean production include mainly inadequate cropping practices.

The application of *A. hypogaea* as an intercropping plant in an agroforestry system of *F. moluccana* and *A. hypogaea* gave profit as much as Rp. 3,015,000.00 ha^{-1} cs^{-1}. That profit could be increased when *A. hypogaea* yield is higher than the yield result in the time of the study. That profit was bigger than the profit of monoculture system of *A. hypogaea* in Central Java Province, but it was smaller than the profit of that in Gorontalo Province and Central Sulawesi Province (Table 7). The difference of total cost could be happened because of the difference in input usage and input price. The number and the price of outputs determine factors affecting revenue. Meanwhile, profit is determined by total revenue and total cost.

Table 3. An average diameter, a mean height, and Mean Annual Increment (MAI) of *Falcataria moluccana* in some plantation systems

Researcher (year)	Important findings
Sudomo (2007)	Agroforestry system of *F. moluccana*-nilam *F. moluccana* diameter: 18 months: 6.85 cm 24 months: 9.48 cm *F. moluccana* height: 18 months: 5.59 m 24 months: 7,28 m
Krisnawati et al. (2011b)	Monoculture system of *F. moluccana* *F. moluccana* diameter: < 4 years: 3.4-16.7 cm 5-10 years: 8.7-40.1 cm 12 years: 24.6-74 cm. *F. moluccana* height: < 4 years: 3.9-19.6 m 5-10 years: 9.9-27.9 m 12 years: 15.3-36.2 m
Mindawati et al. (2013)	Agroforestry system of sengon-coffee-gliricidia-cassava-stick nut and sengon-coffee-cacao-gliricidia-ginger-stick nut *F. moluccana* diameter: 17.2-28.6 cm
Swestiani and Purwaningsih (2013)	MAI *F. moluccana* in agroforestry system: 5.25 cm $year^{-1}$ MAI *F. moluccana* in monoculture system: 3,2 cm $year^{-1}$
Wahyudi and Panjaitan (2013)	*F. moluccana* diameter: Agroforestry system: 3.45 cm $year^{-1}$ Intensive monoculture system: 3.21 cm $year^{-1}$ Conventional monoculture system: 1.99 cm $year^{-1}$

Table 4. *Arachis hypogaea* yield of monoculture and agroforestry systems

Researcher (year)	Farming system	*Arachis hypogaea* yield	Location
Akobundu (1987)	Monoculture system of *A. hypogaea*	3,000 kg ha^{-1} 800 kg ha^{-1}	USA Africa
Najiyati and Danarti (2000)	Monoculture system of *A. hypogaea*	1,200-1,800 kg ha^{-1}	
Swestiani and Purwaningsih (2013)	Monoculture system of *A. hypogaea* Agroforestry system of *F. moluccana* and *A.hypogaea*	1.01 ton ha^{-1} 0.83 ton ha^{-1}	Ciamis District, West Java Province, Indonesia
Riska (2014)	Monoculture system of *A. hypogaea*	1,003.96 kg ha^{-1}	Boya Baliase Village, Marawola Subdistrict, Sigi District, Central Sulawesi Province, Indonesia
Widiyanto and Sudomo (2014)	Monoculture system of *A. hypogaea* Agroforestry system of *F. moluccana* and *A.hypogaea*	1,349.4 kg ha^{-1} 861 kg ha^{-1}	Raksabaya Village, Cimaragas Subdistrict, Ciamis District, West Java Province, Indonesia
This study (2016)	Agroforestry system of *F. moluccana* and *A.hypogaea*	1,000.00 kg ha^{-1}	Forest Education, Forestry Faculty, Universitas Mulawarman, Lempake Subcity, Samarinda City, East Kalimantan Province, Indonesia

Table 5. An average diameter, a mean height, Mean Annual Increment (MAI), and wood production of *Anthocephalus cadamba*

Researcher (year)	**Important findings**
Sudarmo (1957)	MAI *A. cadamba*: Age of 9 years in good-quality sites: 20 m^3 ha^{-1} $year^{-1}$, producing up to 183 m^3 ha^{-1} Age of 9 years in medium-quality sites: 16 m^3 ha^{-1} $year^{-1}$, producing up to 145 m^3 ha^{-1} Age of 9 years in poor-quality site: 15 m^3 ha^{-1} $year^{-1}$, producing up to 105 m^3 ha^{-1}
Soerianegara and Lemmens (1993)	*A cadamba*: an average diameter of 65 cm, a mean height of 39 m, wood production 350 m^3 ha^{-1}
Krisnawati et al. (2011a)	*A. cadamba* diameter at breast height (DBH) < 5 years old: 8-18 cm *A. cadamba* growth > 5 years: Java: diameter 1.2-11.6 cm $year^{-1}$, height 0.8-7.9 m $year^{-1}$ South Kalimantan: diameter 1.2-4.8 cm $year^{-1}$, height 0.8-3.7 m $year^{-1}$ *A. cadamba* height: < 10 years old: 19.6 m > 10 years old: 17.3-30 m

Table 6. *Glycine max* yield on monoculture and agroforestry systems

Researcher (year)	**Plantation system**	***Glycine max* yield**	**Location**
Dogbe et al. (2013)	Monoculture system of *G. max*	509-642 kg ha^{-1}	Saboba and Chereponi Districts, Northern Region of Ghana
Zoundji et al. (2015)	Monoculture system of *G. max*	1,000 kg ha^{-1}	Benin
This study (2016)	Agroforestry system of *A. cadamba* and *G. max*	500 kg ha^{-1}	Forest Education, Forestry Faculty, Universitas Mulawarman, Lempake Subcity, Samarinda City, East Kalimantan Province, Indonesia.

Table 7. Total cost, revenue, and profit of monoculture and agroforestry system of *Arachis hypogaea*

Researcher (year)	**Plantation system**	**Research location**	**Total cost ($Rp.\ ha^{-1}\ cs^{-1}$)**	**Total revenue ($Rp.\ ha^{-1}\ cs^{-1}$)**	**Profit ($Rp.\ ha^{-1}\ cs^{-1}$)**
Muklis et al. (2012)	Monoculture system of *A. hypogaea*	Pasar Anom Village, Grabag Subdistrict, Purworejo District, Central Java Province, Indonesia	7,402,092	9,562,860	2,160,769
Riska (2014)	Monoculture system of *A. hypogaea*	Boya Baliase Village, Marawola Subdistrict, Sigi District, Central Sulawesi Province, Indonesia	3,688,412	15,069,434	11,371,022
Boekoesoe and Saleh (2015)	Monoculture system of *A. hypogaea*	Pulahenti Village, Sumalata Subdistrict, West Gorontalo District, Gorontalo Province, Indonesia	4,049,003	7,600,242	3,551,238
This study (2016)	Agroforestry system of *F. moluccana* and *A. hypogaea*	Forest Education, Forestry Faculty, Universitas Mulawarman, Lempake Subcity, Samarinda City, East Kalimantan Province, Indonesia	10,985,000	14,000,000	3,015,000

The income from the application of an agroforestry system of *F. moluccana* and *A. hypogaea* during four months comes only from the selling of *A. hypogaea* yield. However, a farmer can achieve other income from harvesting the trees in the fifth year. According to Widiyanto and Sudomo (2014), *F. moluccana* has short harvest cycle from 5 to 7 years. The result of a study by Siregar et al. (2007) in East Java Province showed that *F. moluccana* is usually harvested after 10 years; however, there is a tendency to shorten the harvesting time to 8 years. The higher income will come as *F. moluccana* grows taller and its stalk diameter gets bigger.

In the first cropping season in the first year, the application of *G. max* as an intercropping plant in an agroforestry system of *A. cadamba* and *G. max*, gave no profit whereas the farmer loss as much as Rp. 7,519,000.00 ha^{-1} cs^{-1}. The small revenue and the big cost cause little motivation for a farmer to do this system. In the first cropping season, the big portion of capital is to buy *A. cadamba* seedling. In the following cropping seasons, it does not need to buy *A. cadamba* seedling, therefore, production cost will decrease. When there are adequate cropping practices, the *G. max* production will increase. It affects the increase of the revenue, and there is opportunity to reach the higher profit. The result of this study is similar to the result of the study of Dogbe et al. (2013) that found the soybean production in Chereponi District, Northern Region of Ghana is not profitable even though it is done by female who are relatively better than male farmers. On the other hand, soybean production is profitable in Saboba District which is done by male farmers.

The application of an agroforestry system of *A. cadamba* and *G. max* during four months gives income only from the selling of *G. max* yield. When the trees have the best growth of diameter and height, a farmer could harvest them and gets additional income. Logs from tree plantations of *A cadamba* are mostly from young trees with the age of 5-8 years (Hadi et al. 2015). Similar to the agroforestry system of *F. moluccana* and *A. hypogaea*, this agroforestry system gives more than a source of income for farmers.

The results indicate two agroforestry systems of *F. moluccana-A. hypogaea* and *A. cadamba-G. max* are feasible and applicable to rehabilitate the critical lands. Both agroforestry systems give many benefits from the aspect of economy, social, ecology, and conservation. The owner has the possibility to manage their small forest more flexibly and effectively especially in yield arrangement and control (Muliawati 2006). Moreover, if both agroforestry systems are reckoned from the social aspect, it supplies timber product, provides food-stuff, and creates job opportunities for the community. According to Bertomeu (2006), agroforestry systems with wide-spaced trees have the potential of diversifying farm production. The establishment of agroforestry aims to develop the community forest. The application of *A. hypogaea* as an intercropping plant in an agroforestry system of *F. moluccana* and *A. hypogaea* is profitable in the critical lands. From the aspect of the economy, agroforestry system has an important role for community life as a source of income (Senoaji 2012), it produces higher economic returns, and it provides other economic profit (Bertomeu 2006).

In the critical land, the application of *G. max* as an intercropping plant in an agroforestry system of *A. cadamba* and *G. max* in the first year in the first cropping season is not profitable based on economic analysis. However, from the aspect of ecology, agroforestry system can increase land fertility and environment protection (Senoaji 2012). From the aspect of conservation, both agroforestry systems can rehabilitate the critical land. Another study showed that agroforestry systems with wide-spaced trees have environmental benefits derived from tree planting, including erosion control, soil fertility improvement, and windbreaks (Bertomeu 2006). Conservation benefit is also reported by Labata et al. (2012) who found that the agroforestry systems (mixed multistorey system, taungya agroforestry system, and falcata-coffee multistorey system) have the capacity to store carbon in trees, herbaceous vegetation, litter, and soil. According to their study in Bukidnon, Philippines, agroforestry systems can store 92 MgC ha^{-1} to 174 MgC ha^{-1} of carbon.

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