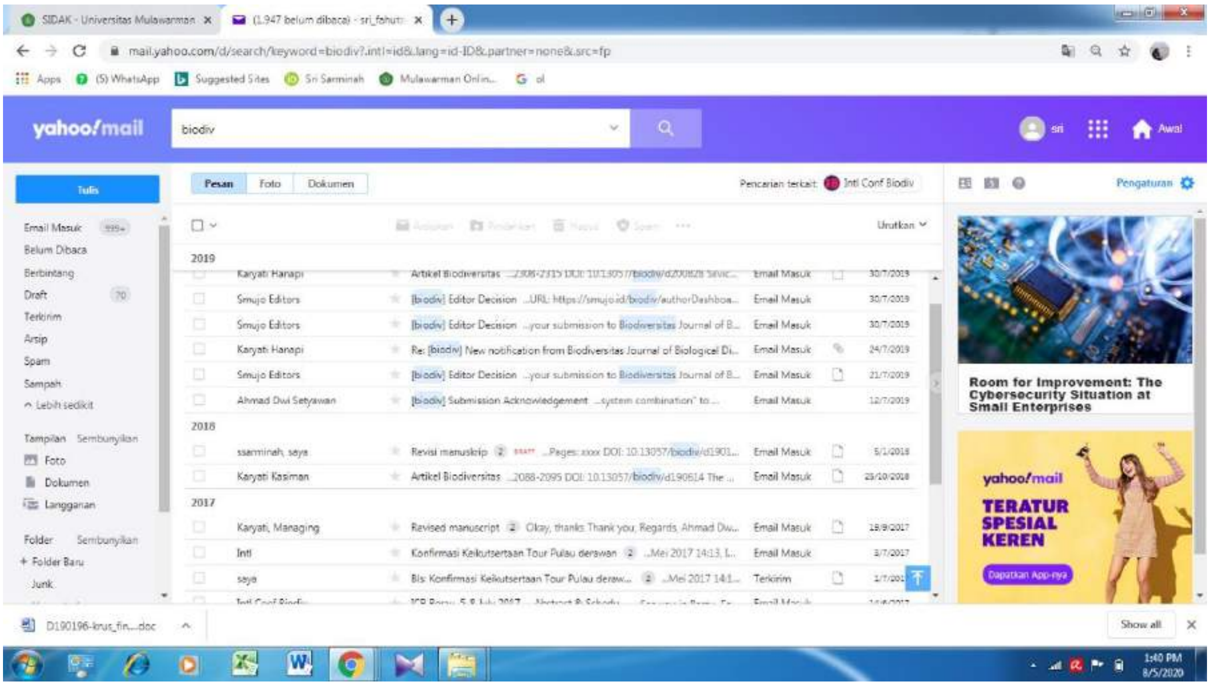
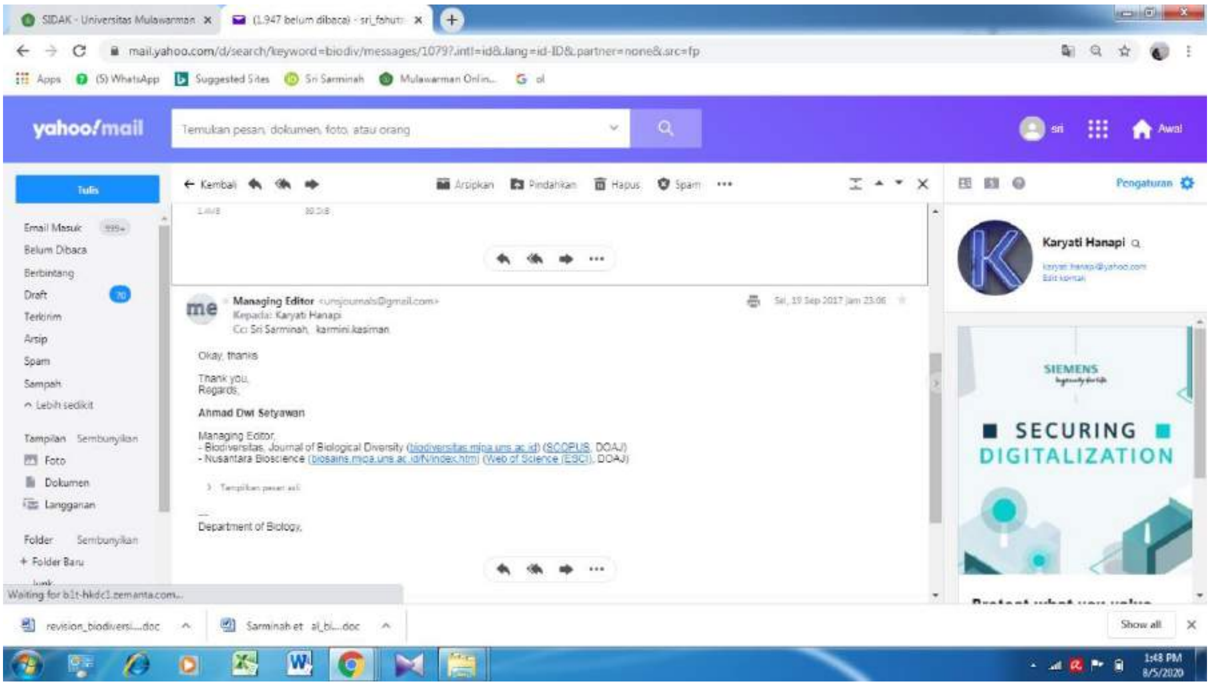
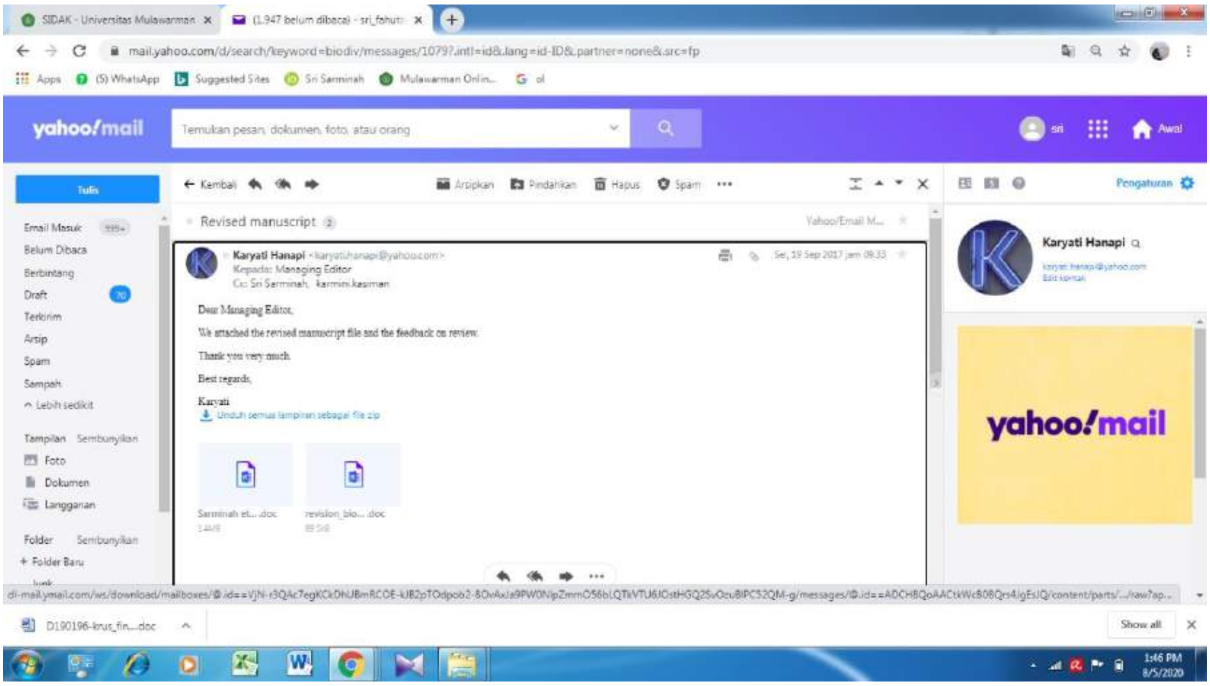
BUKTI-BUKTI PROSES REVIEW (KORESPONDENSI)

Judul	:	Rehabilitation and Soil Conservation of Degraded Land using Sengon (*Falcataria moluccana*) and Peanut (*Arachis hypogaea*) Agroforestry System
Penulis	:	Sri Sarminah, Karyati, Karmini, Jhonatan Simbolon, dan Erikson Tambunan
Nama Jurnal	:	Biodiversitas
Volume/Nomor/Tahun/Halaman	:	19, 1, 2018, 222-228
ISSN	:	1412-033X/E-ISSN: 2085-4722
Penerbit	:	Society for Indonesian Biodiversity
DOI	:	10.13057/biodiv/d190130



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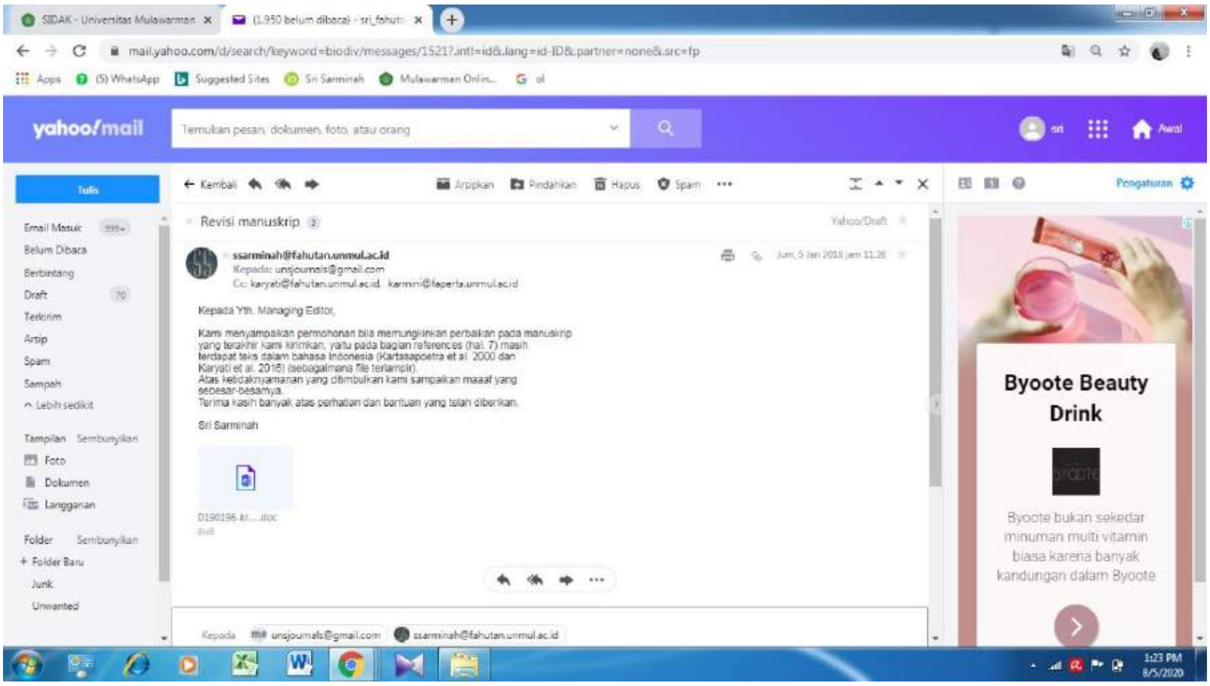
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Land rehabilitation and soil conservation with agroforestry system of sengon (*Falcataria moluccana*) and groundnut (*Arachis hypogaea*) in critical land

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Manuscript received: 1 Juli 2017. Revision accepted: .... 20xx.

ABSTRACT

Land Rehabilitation and Soil Conservation (LRSC) activities in various land conditions are not always successful as expected. The biogeophysical condition in the field and the selection of suitable plant species influence to the success rate of the LRSC. The purpose of this research were to know the growth of agroforestry plant of sengon-groundnut combination and soil and water conservation aspect in critical land. Data analysis covered plant growth, average of diameter and height of sengon as well as parameters hydroorological condition such as potential erosion rate, Erosion Hazard Index (EHI), and Erosion Hazard Class (EHC). The results showed that in rather steep land (slopes of 15-<25%) had the groundnut growth rate of 70-80%, average diameter and height of sengon of 8.25 mm and 58.60 cm at age one month after planting (map) to age four map, potential erosion of 20.05 tons ha^{-1} year^{-1}, EHI of 1.43 (medium), and EHC of Class II. In steep land (slopes of 25-40%) showed the groundnut growth rate of 70-80%, average diameter and height of sengon of 7.90 mm and 54.70 cm at age one month after planting (map) to age four map, potential erosion of 45.50 tons ha^{-1} year^{-1}, EHI of 3.25 (medium), and EHC of Class II. LRSC with agroforestry system on different slopes classes has a positive impact because it reduces the erosion rate.

Key words: Erosion, growth, land rehabilitation, slope, soil conservation.

INTRODUCTION

The critical land will lead the soil becomes no productive and damage slowly. The deforestation causes the soil structure and forest composition be change, and lead the critical lands. Unproductive lands will be critical land because of human activities. The increase of erosion process in critical land is caused by less a wareness of land management. Natural resources utilization that exceeds the carrying capacity of the environments and also population pressure to the land which is not accompanied by soil and water conservation will cause the increasing extend of critical land or environmental unbalancing. Pathak et al. (2017) stated that the conventional practice of annual burning increases soil nutrient in surface soils and supports higher biomass production in *Imperata*-covered degraded lands. Nugroho (2015) reported in 1974 the critical land area reached the size of 10.751.000 ha and it becomes 23.725.552 ha in 1998. Agustinus et al. (2013) suggested implementation of reforestation in Forest Rehabilitation and Land (FRL) program will have many supports and obstacle factors. The efforts to minimize of critical land can be achieved with structural effort (reforestation, afforestation, *check dam*, terrace, etc) and non structural such as involving community people, increasing farmer income, counseling of resources, etc (Nugroho 2015).

Syam (2002) said that the application of land conservation technique should consider three cases i.e. rainfall, land conditions (slope, solum thickness, soil characteristic) and farmer capability (financial, time, and available labor). The right method could produce the critical land rehabilitation strategy. Daswir (2010) conclude that the effort to decrease the land degradation is through adaption of conservation farming systems. The conservation goals are to prevent land degradation, avoid the loss of productive land, increase farming productivity and farmer income, decrease the erosion rate and increase farmer participation resources conservation of soil and water (Syam 2000). Nath et al. (2015) noted that soil organic carbon, water holding capacity, and total nitrogen exhibited highest linear correlation and for the basis for multiple correlation with bamboo (*Bambusa sp.*) productivity in agroforestry systems.

Juhaeti et al. (2005) stated that plants which are able to grow well on critical land have good tolerance to growth on marginal land. Daswir (2010) revealed that a technique of conservation which cheap and easy to be implemented by farmers is alley cropping system. This system is basically planting annual and or annual crops on a farm. The planting of annual plants will cause better micro climate. Karyati (2014a) added that some annual crops require a rainfall range of 500-3000 mm/year, average air temperature of 15-34°C, average air humidity of 70-90%, and pH of 4.0-8.5. The appropriate climatic requirements for vegetables are in the area with rainfall range of 500-2500 mm/year, the air temperature of 15-30°C, the humidity of 50-80%, and the pH of 4.5-8.0 (Karyati 2014b). Generally, leguminous plant species of vegetable crops, annual crops, and forestry crops can grow well in areas with average rainfall, air temperature and humidity in the range of 600-2500 mm/year, 18-40°C, and 50-85% respectively (Karyati 2003; Karyati 2008b). Some legumes are recommended as agricultural crops on agroforestry programs as well as intercrops at the beginning of palm oil planting (Karyati 2012a). Sarminah (2014) mentions the modeling of Land Rehabilitation and Soil Conservation (LRSC) techniques for land rehabilitation and soil and water conservation need the appropriate consideration of plants. Legum cover crops (LCC) are a type of creeping legume is planted and related among annual crops, and as be pioneer plant for the rehabilitation of land degradation (Idjudin 2011).

Some researches about the use of legumes such as soybean (*Glycne max*) and groundnuts (*Arachis hypogeae*) on reforestation and rehabilitation activities have been done by Catharina (2009), Raja et al. (2013), Sarawa et al. (2014), Sembiring et al. (2014), and Yuliawati et al. (2014). The successful of planting of jabon (*Anthocephalus cadamba*) and sengon (*Falcataria moluccana*) in Land Rehabilitation and Soil Conservation (LRSC) effort on critical land have been reported by Ainingsih et al. (2016), Hairiah et al. (2004), Siarudin and Suhaendah (2007), Sudomo (2007), Wahyudi and Panjaitan (2013), and Wasis et al. (2015).

In fact, the implementation of LRSC program in various land conditions doesn't always work as expected. This is because the LRSC activities are influenced by several factors, such as biogeophysical conditions of the field as well as socio-economic and cultural societies. The selection of appropriate plant species combinations in different slope classes greatly determines the succession of LRSC implementation in terms of soil and water conservation aspects as well as the economic aspects. Karmini et al. (2017) proved that the agroforestry system of sengon – groundnut in East Kalimantan result that benefit from the economic aspect with a profit gain of Rp 3,015,000.00 ha/planting season (226.96 USD ha/planting season). The purposes of this research were to determine the growth of agroforestry plant (combination of sengon – groundnuts) and the soil and water conservation aspect in critical land. The importance of application of LRSC model using agroforestry system is a policy alternative that can be applied and developed on critical land in order to suppress the rate of surface runoff and eroded soil mass. Present work also aims to explore the appropriate vegetative technique with the consideration of simple technology, raw material availability, rapid growth, cheap cost that can be applied massively on a wider scale critical land.

MATERIALS AND METHODS

Study area

The research was conducted on critical land area Education Forest of Forestry Faculty of Mulawarman University, Lempake Sub-district, Samarinda City, East Kalimantan Province. Research activities were carried out for 6 (six) months from January to June 2017. The map of the study area is presented in Figure 1. The Education Forest of Forestry Faculty of Mulawarman University covers about 300 hectares in low land rain forest. It consists of primary forest secondary and secondary forest. Because of forest fire in 1997 and 1998 the primary forest were became the young secondary forest. The soil in this area is classified into yellow podsolic type and soil texture of sandy loam (Tropical Forest Research Center 2016). The physiographic and topographic state of the Education Forest of Forestry Faculty of Mulawarman University between 50-100 m above sea level with bumpy reliefs up to slightly hilly and altitude ranges from 52-76 meter above sea level (Boer et al. 1988). The initial vegetation is a natural forest which dominated by Dipterocarpaceae. After forest fires in 1983, 1993 and 1998, vegetation mostly turns into young secondary forest and now turns to an old secondary forest that leads to climax process (KRUS 2013; KRUS 2014).

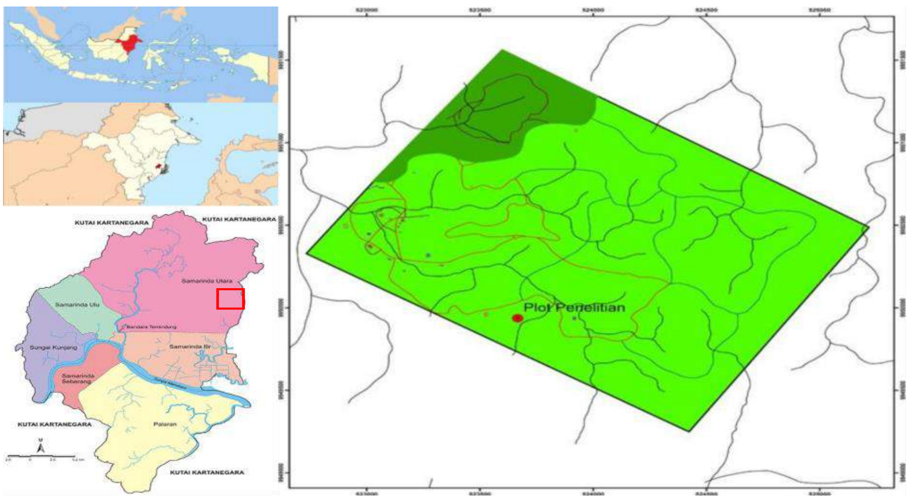

Figure 1. Map showing research area location in Education Forest of Forestry Faculty of Mulawarman University, Samarinda, East Kalimantan, Indonesia.

Procedures

The location of this research was on critical categorized land with rather steep slopes of 15-<25% (Trial Plot 1= TP 1) and steep slope of 25-40% (Trial Plot 2 = TP 2). Two trial plots of 10 m × 10 m were established in each slope class. The selected forestry crops of sengon (*Falcataria moluccana*) were planted in spacing of 3 m × 3 m. The legume cover crops of groundnut (*Arachis hypogaea* L.) were planted as intercrops. Planting was done on two different slope classes of 15-<25% and 25-40%. The representative erosion plot sized 10 m × 3 m was established in each trial plot. The observed hydrological aspects were potential erosion rate (A), Erosion Hazard Index (EHI), and Erosion Hazard Class (EHC) (Hammer 1981). Measurements of hydrological parameters were done as much as 35 times of rainfall. Plant preserved by watering, weeding, fertilizing, and controlling pests and plant diseases. In the end, the legume cover crops were only harvested and no harvesting for forestry plant.

Data analysis

The observations and measurements of plant growth were carried out for four months. Measurement of diameter and height for sengon (*Falcataria moluccana*) was done every month. While groundnut crops were percentage of plant coverage. This study analyzed the plant growth such as the increment of diameter and height of forestry plants and the percentage of plant coverage of groundnut. The observed hydro orology parameters were the potential erosion rate (A), run off, Erosion Hazard Index (EHI), and Erosion Hazard Class (EHC).

RESULTS AND DISCUSSION

The growth of sengon and groundnut

Based on the growth of the two plant species, it can be categorized as good. It means the plants grew well with lots of shoots and leaves. Generally, sengon and groundnut showed the healthy growth, although groundnut growth was not consistent in rather steep slope class (TP 1) and steep slope class (TP 2). The growth of sengon exhibited increase in diameter and height. A qualitative analysis of agroforestry plant growth is presented in Table 1.

Table 1. The qualitative analysis of sengon and groundnut growth in different slope classes.

No.	Plants	TP 1 Month -				TP 2 Month -			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1.	Sengon	M	G	G	G	M	M	G	G
2.	Groundnut	M	G	G	G	M	M	G	G

Note: TP 1 = Rather steep slope class (15-<25%); TP 2 = Steep slope class (25-40%); M = Moderate; G = Good.

The basic advantages of land rehabilitation vegetatively cover three steps including: (1) control of surface runoff and erosion, (2) reduce the direct impact of rainfall detention on land surface and (3) improve the land condition that lead the productive purposes later. The growth percentage of sengon was 100% in both TP, while coverage percentage of groundnut in TP 1 and TP 2 reached about 70-80% as shown in Figure 2. The application of fertilizer (NPK) influences to growth and coverage of groundnut the effort of rehabilitation of critical land.

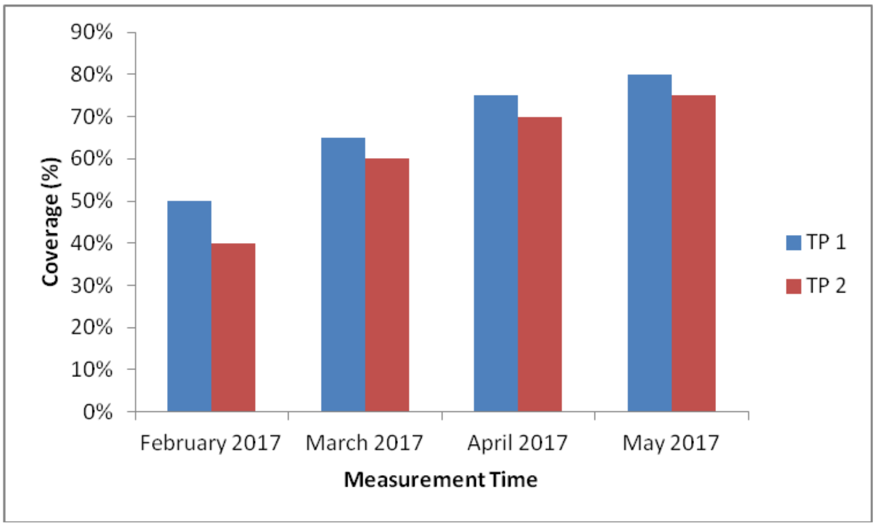

Figure 2. Coverage percentage of groundnut.

The diameter and the height increments of sengon in the different slope classes

The diameter and height increments of sengon in different slope classes during the study were shown in Tables 2 and 3. In rather steep slope class (TP 1), the average of sengon diameter and height increments in 1st month after planting (map) to 4th map were 8.25 mm and 58.60 cm, respectively. While in steep slope class (TP 2) the average of sengon diameter and height increments in 1st map to 4th map were 7.90 mm and 54.70 cm, respectively. The occurrence of the difference in value is due to the slope, where if the rainfall in the steep slopes (25-40%) there are many more nutrient leaching occurs than in rather steep slopes (15-<25%). It will affect to sengon growth, especially diameter and height. The average diameter increment of sengon in the different slope classes is higher than the increments of dominant tree species in the secondary tropical forest. Karyati et al (2017) reported that the average diameter increments for the entire selected species were 0.86 cm year^{-1} for periodic measurement and 0.75 cm year^{-1} for monthly measurement.

Table 2. The diameter increment of sengon in different slope classes.

Tree number	**TP 1**					**TP 2**				
	D_0 (mm)	**d_1 (mm)**	**d_2 (mm)**	**d_3 (mm)**	**d_4 (mm)**	**D_0 (mm)**	**d_1 (mm)**	**d_2 (mm)**	**d_3 (mm)**	**d_4 (mm)**
1	1.32	3.26	4.88	6.80	8.05	1.57	2.08	3.03	5.31	7.55
2	1.42	2.50	4.91	7.10	8.10	1.02	2.15	3.74	6.46	8.20
3	1.12	3.68	4.82	6.50	7.95	1.17	2.31	3.09	5.53	7.35
4	1.68	3.04	4.18	6.31	7.85	1.87	2.34	4.15	5.55	7.70
5	1.59	3.25	4.47	6.97	8.10	1.66	2.71	4.43	6.88	8.05
6	1.39	3.18	4.84	6.50	8.20	1.46	3.07	4.02	5.59	7.65
7	1.20	3.08	4.36	6.94	8.05	1.13	3.23	4.12	5.27	8.10
8	2.81	2.49	3.93	6.81	8.00	1.10	3.43	4.74	5.00	7.85
9	2.11	3.01	4.26	7.00	8.70	1.13	3.70	4.74	5.62	7.60
10	1.02	2.69	4.16	7.20	9.20	1.19	3.74	4.44	5.28	7.40
11	1.66	2.32	3.68	6.24	8.40	1.12	3.66	4.87	5.75	8.40
12	1.79	2.44	3.97	6.91	8.80	1.53	3.07	4.47	5.49	8.30
13	1.59	2.38	3.89	6.06	8.50	1.00	2.84	3.12	5.05	7.90
14	1.63	2.79	4.00	6.67	8.00	1.88	2.16	4.14	4.78	7.95
15	1.52	2.61	3.90	6.57	7.90	1.68	3.93	4.53	6.17	8.20
16	1.02	2.47	3.87	6.98	8.20	1.39	3.65	4.10	6.13	8.20
Average	1.55	2.82	4.26	6.72	8.25	1.37	3.00	4.11	5.62	7.90
SD	0.44	0.40	0.41	0.33	0.38	0.30	0.65	0.59	0.56	0.33

Note: TP 1 = Rather steep slope class (15-<25%); TP 2 = Steep slope class (25-40%); D_0 = The initial diameter; d_1, d_2, d_3, d_4 = The diameter increment in first, second, third and fourth months, respectively; SD = standard deviation.

Table 3. The height increment of sengon in the different slope classes

Tree number	TP 1					TP 2				
	H_0 (cm)	h_1 (cm)	h_2 (cm)	h_3 (cm)	h_4 (cm)	H_0 (cm)	h_1 (cm)	h_2 (cm)	h_3 (cm)	h_4 (cm)
1	54	25	33	49	58	58	24	34	44	54
2	54	26	35	52	61	60	27	37	47	57
3	53	27	32	48	58	56	23	33	43	54
4	59	29	35	47	58	56	24	34	44	54
5	57	27	35	47	57	55	23	33	43	53
6	57	28	36	48	59	57	25	35	45	55
7	58	29	39	50	61	56	25	35	45	56
8	59	28	35	49	58	55	24	34	44	54
9	61	31	43	54	60	57	26	36	46	56
10	56	29	38	49	56	56	23	33	43	53
11	55	27	37	43	57	54	22	32	42	52
12	56	29	32	47	60	55	25	36	46	57
13	57	28	33	49	60	56	26	36	46	56
14	54	25	36	48	58	55	24	34	44	54
15	60	33	42	50	57	54	22	32	42	53
16	60	34	46	51	60	59	27	36	46	57
Average	57.00	28.44	36.69	48.81	58.60	56.00	24.38	34.38	44.38	54.70
SD	2.47	2.53	4.05	2.46	1.54	1.68	1.59	1.54	1.54	1.62

Note: TP 1 = Rather steep slope class (15-<25%); TP 2 = Steep slope class (25-40%); H_0 = The initial height; d_1,d_2, d_3, d_4 = The height increment in first, second, third and fourth months, respectively; SD = standard deviation.

The results showed that the increase in diameter and height of sengon every month are caused by: (1) The effect of intercropping crops (groundnuts) which the addition of organic ingredients through decomposed fallen groundnut leaves,

(2) the fertilization of NPK aims to increase the nutrient supply needed by the plant to increase crops production and quality, (3) sengon is included fast growing plants, which lead a significant diameter growth, (4) Preservation the plant, watering done to avoid drought and water supply for plants to support the diameter increment (Murbandono 2001). The fertilization of NPK gives a considerable supply of N to the soil, and helps the sengon diameter growth. Fertilizer provides nutrients that are lacking or even not available on the ground to support plant growth. The benefits of fertilizers relate to soil physical properties to improve soil structure by the providing space on the ground for air and water.

Kartasapoetra et al. (1991) said that slope is the most important factor, whereas steeps slope is more easily hampered and suffered damage mainly by erosion damage. Cover crop growth in TP 1 is more evenly compared than in TP 2 influence the diameter and height increments of sengon. The function of cover crop is to increase soil fertility through decay of deciduous leaves (organic matter). This is supported by the results of laboratory analysis that there is an increase in soil nutrient elements. In the beginning of study, the soil analysis showed the soil pH was 4.26. The soil pH was increase (4.9) in the end of study. The difference in the height increment in two slope classes is also influenced by the nutrient absorption of the plant itself and the ability of photosynthesis to obtain optimal results (Sari 2002).

The hydroorological aspect

During the study period, rainfall measurements were carried out as much as 35 times of rainfall. The average rainfall during the study was 20.62 mm/day. Surface runoff (SRo), potential erosion rate (A), Erosion Hazard Index (EHI) and Erosion Hazard Class (EHC) in both Erosion Measurement Plots (EMP) are presented in Table 4.

Table 4. Surface runoff (SRo), potential erosion (A), erosion hazard index (EHI), and erosion hazard class (EHC) in different slope classes.

Slope Classes	SRo (m^3/ha/th)	A (ton/ha/th)	EHI	EHC
15-<25%	794.55	20.05	1.43 (Medium)	II (Low)
25-40%	846.61	45.50	3.25 (Medium)	II (Low)

The result showed that the steeper slope leads the greater surface runoff, so the amount of potential erosion is also greater. In addition, the soil texture also affected the amount of the potential erosion. The analysis of soil texture showed Sandy Loam texture in the study area, that it has smoother texture properties. The fine-textured soil usually has a small infiltration capacity, so that even low rainfall will cause surface runoff.

Dust and fine sand are difficult to form a stable structure, because the cohesion between the particles is very weak and therefore the soil contain high dust and fine sand is more sensitive to erosion (A'Yunin 2008). Evaluation of erosion hazard is an assessment or prediction of the extent of soil erosion and its potential danger to a plot of land. This erosion hazard evaluation is based on the results of land evaluation and according to its level. To determine the incidence of erosion at the level of harm or a threat of land degradation or not, can be known from the level of erosion hazard from the land. Based on the observation of soil profile in the research area, it is known that the soil depth reaches> 100 cm so that Soil Loss Tolerance is 14 ton / ha / year (Dwiatmo 1982). The result showed that the potential erosion rate in the different slope classes exceeds tolerable threshold, are in a moderate level at least still able to suppress the rate of erosion. The Erosion Hazard Index (EHI) values on rather steep slope and steep slope 1.43 (moderate value) and 3.25 (moderate value) respectively. EHC in two slope classes including class II (soil depth of > 90 cm) and the range of potential soil erosion is 15 to 60 ton/ha/year. Land Rehabilitation and Soil Conservation (LRSC) with agroforestry system in different slope classes have a positive impact because it can suppress the rate of erosion to the Erosion Hazard Class of low.

The groundnut-sengon agroforestry system applied to Land Rehabilitation and Soil Conservation on degraded land gives a significant result, because there is an increase in diameter and high increments in sengon as well as land cover (groundnut) yield is also significant. It is expected that the results of this research can be applied on a wide scale because in terms of ecology and economics aspects are very profitable, and recommended to be applied to the stakeholders and government in this case the Ministry of Environment and Forestry Indonesia and the Ministry of Agriculture of Indonesia.

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The comment on review of manuscript “Land rehabilitation and soil conservation with agroforestry system of sengon (*Falcataria moluccana*) and groundnut (*Arachis hypogaea*) in critical land”.

Line	Review	Feedback and revision
General comments (from email):		
Introduction and methodology section	Major revision	Revised
Comments through track changes:		
Line 23-27 Introduction	Too general	Removed
Line 32-33 Introduction	…said that…	Revised → …reported … (line 31)
Line 34 Introduction	…said that…	Revised → …suggested … (line 32)
Line 35 Introduction	…has …	Revised → … will have … (line 32)
Line 35 Introduction	…done …	Revised → … achieved … (line 33)
Line 41 Introduction	…by the application of farming conservation system.	Revised → …through adoption of conservation farming systems (line 39)
Line 47 Introduction	… *micro climate*.	Revised → … micro climate (not italic) (line 47)
Line 69 Introduction	…Rp 3,015,000,00 ha/planting season.	Added equivalent currency in terms of US $ → … Rp 3,015,000,00 ha/planting season (226.96 USD ha/planting season) (lines 69-70)
Line 73 Introduction	It is also to find the appropriate …	Revised → Present work also aims to explore the appropriate … (line 73)
Line 80 Materials and Methods	The map of location research …	Revised → The map of the study area is peresented …
Line 85 Materials and Methods	Figure 1. Research location in Education Forest …	Revised → Map showing research area location in Education Forest … (line 80)
Line 89-92 Materials and Methods	No standard methodologies for soil physical and chemical properties.	We had deleted the procedure of soil physical and chemical properties, because we did not discuss this section in Results and Discussion.
Line 93 & 94 Materials and Methods	Scientific name should be in italics	Revised (line 114)
Line 95 Materials and Methods	The erosion plot …	Revised → The representative erosion plot … because the erosion plot sized 10 m × 3 m was in the trial plot of 10 m × 10 m (line 115)

Line	Review	Feedback and revision
Line 96-97 Materials and Methods	Give citation of these indeces in the text	Added →… (Hammer 1981) (line 117)
Line 107-116 Study area in Result and Discussion section	This section must go under Material and Methods section	Moved to Material and Methods section (lines 80-88)
Line 117 Result and Discussion	… dan …	Revised → …and … (line 127)
Line 118-122 Result and Discussion	Based on what their growth have been categorized as good.	Revised and added the explanation (lines 128-129).
Line 118-122 Results and Discussion	The edited sentences → Based on …. Table 1.	Edited sentences as the suggestion (lines 128-131)
Line 144-145 Table 2	Instead of showing replication values, mean values can be graphically represented with SE on the line bar	Revised and added standard deviation (SD) in last line of Table 2.
Line 150-151 Table 3	Instead of showing replication values, mean values can be graphically represented with SE on the line bar	Revised and added standard deviation (SD) in last line of Table 3.
Line 155 Result and Discussion	… the increasing of …	Revised → …the increase in … (line 184)
Line 162-163 Result and Discussion	Delete, too general sentence	The sentence was deleted.
Line 203 Result and Discussion	Add a section on the implication of the study	Added in the last paragraph of Result and Discussion (lines 224-228).
Line 205-210 Result and Discussion	Add few more reference on agroforestry and soil management in Introduction part.	Added two references in Introduction part as suggested (Nath et al 2015 & Pathak et al 2017)→Introduction (lines 41-43 & 29-30) → References (lines 263-264 & 268-269)

Samarinda, 18 September 2017

Best regards,

Karyati

BIODIVERSITAS
Volume 19, Number 1, January 2018
Pages: xxxx

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d1901xx

Rehabilitation and soil conservation of degraded land using sengon (*Falcataria moluccana*) and peanut (*Arachis hypogaea*) agroforestry system

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Tel.: +62-541-35089, Fax. +62-541-732146, ♥email: ssarminah@fahutan.unmul.ac.id, ♥♥ karyati@fahutan.unmul.ac.id
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Manuscript received: 1 July 2017. Revision accepted: xxx December 2017.

Abstract. *Sarminah S, Karyati, Karmini, Simbolon J, Tambunan E. 2018. Rehabilitation and soil conservation of degraded land using sengon (*Falcataria moluccana*) and peanut (*Arachis hypogaea*) agroforestry system. Biodiversitas 19: xxxx.* Rehabilitation and soil conservation effort on degraded lands is not always a success. Multiple factors, such as the field' biogeophysical conditions and the choice of suitable plant species determine the effectivity of the rehabilitation program. Our research aimed to implement agroforestry system of sengon (*Falcataria moluccana*) and peanut (*Arachis hypogaea*) on degraded land at different soil slopes (a steep and a slightly steep slope gradient) and to analyze the effect of the system on silvicultural and hydro-orological aspects of the degraded land. The silvicultural parameters examined in this study were the ground coverage of peanut growth and the stem diameter and height of sengon trees. Meanwhile, the hydro-orological parameters included potential erosion rate, erosion hazard index, and erosion hazard level. Our study revealed that on the land with the slightly steep slope (15-25%), the survival rate of sengon reached 90%, the ground coverage of the peanuts was 70-80%, the diameter and height increment of sengon trees reached 2.47 cm/year and 17.58 cm/year, respectively. Meanwhile, the potential erosion rate was 20.05 ton/ha/year, with an erosion hazard index of 0.80 (low) and a low hazard level. In the steeper ground (25-40%), the survival rate of sengon reached 90%, the peanut coverage was 50-60% and the diameter and height increment of the sengon were 2.37 cm/year and 16.41 cm/year, respectively. In the steep ground, potential erosion rate was 45.50 ton/ha/year, with an erosion hazard index of 3.25 (moderate) and a low hazard level. We concluded that the rehabilitation and soil conservation using sengon-peanut agroforestry system effectively suppressed erosion rate to a low erosion hazard.

Keywords: Erosion, slope, soil conservation, growth, land rehabilitation

INTRODUCTION

Critical lands suffer from low productivity and are gradually degraded. Forest damage affects the forest structure and composition, which in turn lead to the formation of unproductive lands. These degraded lands become increasingly critical due to erosion triggered by careless and irresponsible human activities. Exploitation of natural resources beyond the environment carrying capacity and human pressure to the land without proper soil and water conservation measures will result in an ecological imbalance as represented by the increasing number of degraded land. Pathak et al. (2017) stated that annual controlled fires replenish the soil nutrients and promote higher production of biomass in degraded lands infested with cogon grass weed. Nugroho (2000) reported that in 1974, the total area of degraded land in Indonesia reached 10,751,000 ha and increased to 23,725,552 ha in 1998. Efforts to minimalize the rate of land degradation can be done structurally (reforestation, afforestation, terracing, check dam construction, etc.) and non-structurally by involving the participation of the community, improving the income of the people, counseling, etc. (Nugroho 2000).

According to Daswir (2010), one way to suppress land degradation is by implementing conservation agricultural system. The system involves farmers in the soil and water conservation endeavors. Conservation agriculture practices can prevent further land degradation and the loss of productive soil, suppress erosion, and increase the farming productivity and the income of the farmer (Syam 2003). Syam (2003) added that soil conservation, in particular, must take into account three critical factors, rainfall intensity, land condition (slope, column thickness, and soil properties), and farmer's situation (cost, time, and labor).

Rehabilitation of degraded lands can be done by using vegetative conservation, mechanical conservation or combination of vegetative and mechanical conservation approaches. Vegetative conservation is a widely used and recommended soil and water conservation technique due to its convenient nature. Matching plant species with the land site is crucial in implementing vegetative conservation. Juhaeti et al. (2005) stated that a plant species that can grow well in a degraded land indicates that that species has a right tolerance toward such type of marginal land. Daswir (2010) suggested alley cropping as an economical and straightforward conservation method for farmers. Alley cropping is planting annual crops in between rows of trees or hedges. Alley cropping provides microclimate benefit to the annual crop. In general, leguminous vegetables, annual crops, and forest crops can grow well in an area with 600-

2500 mm/year rainfall, 18-35°C temperature, and 50-85% relative humidity (Karyati 2003, 2008).

Sarminah (2014) suggested that the choice of plant species for land rehabilitation and water and soil conservation program must be carefully taken into consideration. In general, ground cover plants are vine-type legumes that are planted in between the annual crops, grown alternatively with the annual crops, or raised as pioneer crops in degraded land rehabilitation (Idjudin 2011). The merit of sengon (*Falcataria moluccana*) as forest tree species for agroforestry has been reported by Sudomo (2007) and Wahyudi and Panjaitan (2013). In addition to the suitable plant species, the success of land rehabilitation project is determined by the proper combination of the plants constituting the agroforestry system. The combination must not only satisfy the biogeophysical condition of the land but also be compatible with the social, economic, and cultural aspect of the local community. Karmini et al. (2017) reported that sengon-peanut-based agroforestry system in East Kalimantan made a profit of Rp 3,015,000.00/ha/season (226.96 USD/ha/season).

As an alternative land rehabilitation policy, agroforestry system is viable to be applied on a degraded land. Agroforestry offers generous benefits, it is a relatively simple technology with widely available resources; plants are quick and easy to grow, and it has a low cost even upon large-scale application on degraded land. Thus, this study aims to implement an agroforestry system of sengon and peanut on degraded land with different soil slopes (a steep and a slightly steep slope gradient) and to analyze the effect of the system on silvicultural and hydro-orological aspects of that land.

MATERIALS AND METHODS

Study location

This research was conducted on a degraded land located in the Education Forest of Forestry Faculty, Mulawarman University, Lempake Sub-district, Samarinda City, East Kalimantan Province, Indonesia. The study took place for six months from January to June 2017. The experimental forest had a total area of 300 ha and was geographically located at 0°25'10"-0°25'24" South latitude and 117°14'00"-117°14'14" East longitude, in between The Samarinda-Bontang Highways Kilometers 10 and 13. The experimental forest is administratively situated in Tanah Merah Village, North Samarinda Sub-district, Samarinda City, East Kalimantan Province. The forest is bordered by Sempaja Village to the north, Mugirejo Village to the south, Lempake Village to the west, and Sungai Siring Village to the east (KRUS 2013; KRUS 2014). The study location map is shown in Figure 1.

According to Meteorological, Climatological, and Geophysical Agency of Indonesia (BMKG), during the last seven years, the research location encountered 211.5 mm monthly rainfall, 27.4°C average temperature, 82.2% relative humidity, and 41.8 hours average irradiation (Karyati 2015). The daily temperature inside the forest ranged 23.7°C-30.9°C, while the outside temperature was 25.9°C-28.8°C. Daily relative humidity inside and outside the forest were 81.4%-99.3% and 76.0%-90.0%, respectively. The daily average light intensity ranged from 1.08 μmol to 18.41 μmol (Karyati and Ardianto 2016). According to Schimdt-Ferguson (1951) system, the climate of Samarinda City was classified as type A climate, with a quotient (Q) of 0.048, which means that the city is highly humid with a tropical rainforest vegetation (Karyati et al. 2016).

The experimental forest is a lowland tropical rainforest located about 50 m above sea level. The forest was initially a natural forest composed predominantly with Dipterocarpaceae. After fires in 1983, 1993, and 1998, the forest stabilized and became an early secondary forest. Now, the forest has been in a late secondary forest stage and on its way toward climax state. Some of the plant species predominantly found in the forest were ulin (*Eusideroxylon zwageri*), puspa (*Schima wallichii*), medang (*Litsea* spp.), meranti (*Shorea* spp.), etc. Meanwhile, animals found in the forest were invertebrates such as protozoa, annelids, mollusks, crustacean, insects, arachnoids; and vertebrates including fish, frogs, birds, reptiles, and mammals (KRUS 2013; KRUS 2014).

Instruments and materials

Tools and instruments that used in this study included measuring tape, clinometer, compass, diameter measuring tape (phi-band), microcaliper, machete, hoe, sickle, galvanized zinc roof sheets, PVC pipe, drum, ruler, soil sampling ring, ombrometer, graduated cylinder, filter paper, bucket, hand sprayer, camera, and stationery.

Experimental procedures

10 m x 10 m experimental plots were prepared for two different slope classes in the experimental forest area, a slightly steep slope (15-25%, henceforth called Plot 1), and a steep slope (25-40%, henceforth called Plot 2). Sengon (*Falcataria moluccana*) and peanut (*Arachis hypogaea* L.) were grown on both plots. Sengon trees were planted with a spacing of 3 m × 3 m. Peanut, as the groundcover legumes were planted in between the sengon trees. 10 m × 3 m erosion measurement plots, were arranged on the two experimental plots. Hydro-orological parameters measurements were conducted at 35 times rain events. Plant maintenance was performed accordingly, including watering, weeding, fertilizer application, and pest and plant diseases control. Harvesting was done on the groundcover peanut produce and not on the sengon trees.

Analysis of soil properties

For soil profile description, a soil pit with the depth of 1.5 meter was dug at the center of study plot. Soil profile descriptions were conducted adopting the standard procedures by International Soil Science Society (ISSS) (NRCS 2002). The soil profile description was conducted by observing the characteristics of the soils moving towards the bottom of profile. Some of the characteristics were distinguished such as depth and field texture.

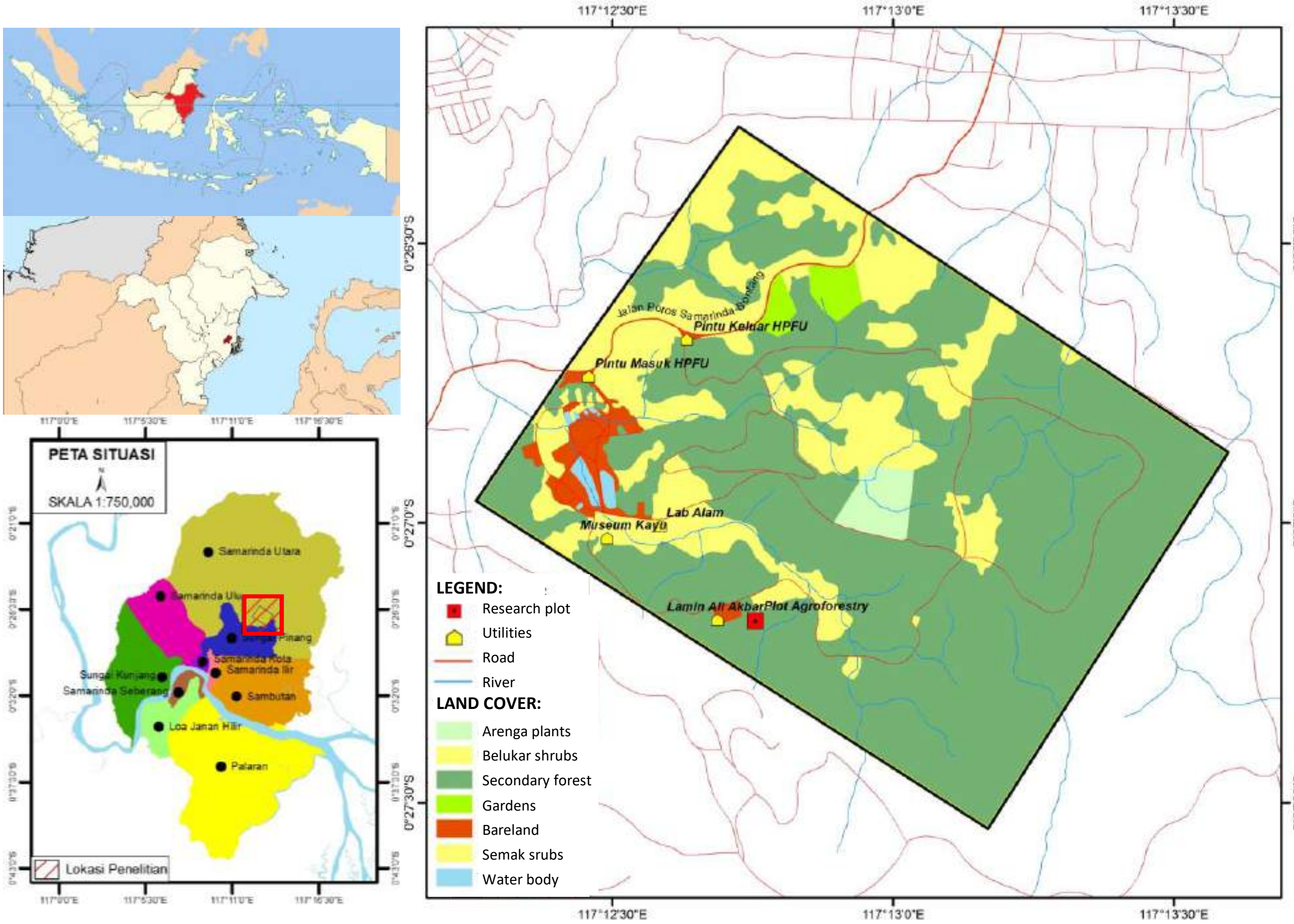

Figure 1. Study location in the Education Forest of Forestry Faculty, Mulawarman University, Samarinda, Indonesia

The analysis of soil physicochemical properties (pH (H_2O), pH (KCl), C organic, total N, P, K, and texture) were conducted in Laboratory of Soil Science, Tropical Forest Research Center, Mulawarman University, Samarinda, Indonesia. Soil pH was determined in distilled water and 1 N KCl in a soil to solution ratio of 1:2.5 by the glass electrode method. The total nitrogen (total N) was analyzed using Kjeldahl method. Soil P and K were analyzed using Bray 1 method.

Data analysis

Plant growth observation and measurement were done at the end of every month for four months. The observation was carried out on both sengon and peanut plants. In addition, sengon's survival rate, peanut's ground coverage, and sengon tree height and diameter were measured as well. Hydro-orological parameters measured in this study included surface runoff, potential soil erosion rate, erosion hazard index, and erosion hazard level (Hammer 1981). Classification of erosion hazard index and erosion hazard level are presented in Table 1 and Table 2, respectively. Formula to determine erosion hazard index is as follows (Hammer 1981):

Erosion hazard index = Potential erosion rate (ton/ha/year) / Tolerable erosion rate (ton/ha/year)

Table 1. Erosion hazard index categories (Hammer 1981)

Erosion hazard index	**Category**
< 1.00	Low
1,01-4,00	Moderate
4,01-10,00	High
> 10,01	Very high

Table 2. Erosion hazard level classification

Soil column (cm)	**Erosion rate (ton/ha/year)**				
	<15	**15-<60**	**60-<180**	**180-480**	**>480**
Deep (>90)	Very low	Low	Moderate	High	Very high
Intermediate (60-90)	Low	Moderate	High	Very high	Very high
Shallow (30-<60)	Moderate	High	Very high	Very high	Very high
Very shallow (<30)	High	Very high	Very high	Very high	Very high

Source: Regulation of Directorate General of Watershed Management and Social Forestry, Ministry of Forestry Republic of Indonesia (2013)

RESULTS AND DISCUSSION

Silviculture aspect

In general, sengon and peanut grew well and healthy, as indicated by the formation of dense shoots and leaves. During the first two weeks, the peanut growth had yet to grow evenly both in Plot 1 and Plot 2. The qualitative evaluation of sengon and peanut growth are summarized in Table 3.

Qualitative evaluation was conducted based on visual observation of sengon and peanut plants in the field (Table 3). A well-grown plant was described as a plant with a vigorous appearance, fresh green leaves, normal stem growth, densely grown flowers, and a canopy coverage as high as 80%. Fairly grown plant was described as a plant with relatively fair body vigor, mostly green leaves with very few yellow leaves, a stem size ranged from small to big, relatively less dense flowers, and a canopy coverage of less than 60%. Observation at the end of study revealed that sengon trees in Plot 1 and Plot 2 exhibited a high survival rate of about 90% (Figure 2). This result indicates that the sengon trees can grow well in such a critical land. Ground coverage of peanut plants grown in Plot 1 and Plot 2 were 70-80% and 50-60%, respectively (Figure 3).

Table 4 and 5 show the monthly diameter and the height increments of sengon trees, respectively, that were monitored for 4 months. Judging from these results, sengon trees on the slightly steep slope (Plot 1) show a better growth performance in term of diameter and height increment compared with sengon trees on the steeper slope (Plot 2). The mean stem diameter increment of sengon located on the less steep and on the steep slope is 2.47 cm/year and 2.37 cm/year, respectively. Meanwhile, the height increments of sengon trees on the slightly steep and the steep slopes are 17.58 cm/year and 16.41 cm/year, respectively. Sengon diameter increment obtained in our agroforestry system is lower than those of the previous study by Swestiani and Purwaningsih (2013). They reported that the mean annual diameter increment of sengon grown on an agroforestry system and a monoculture system were 5.25 cm/year and 3.20 cm/year respectively. Similarly, a study by Wahyudi and Panjaitan (2013) reported that sengon grown on an agroforestry system showed the highest diameter increment (3.45 cm/year) compared with that of the sengon cultivated in an intensive monoculture (3.21 cm/year) and a conventional monoculture system (1.99 cm/year). Interestingly, the diameter increments of sengon obtained in this study were higher than that of predominant trees grown in a secondary tropical forest (0.75-0.86 cm/year) (Karyati et al. 2017). In a study on agroforestry system cultivating a combination of sengon and nilam, Sudomo (2007) reported that 18-month-old sengon exhibited a stem diameter and a height of 6.85 cm and 5.59 cm, respectively. Whereas, at 24 months of age, the sengon reached 9.48 cm in diameter and 7.28 m in height (Sudomo 2007).

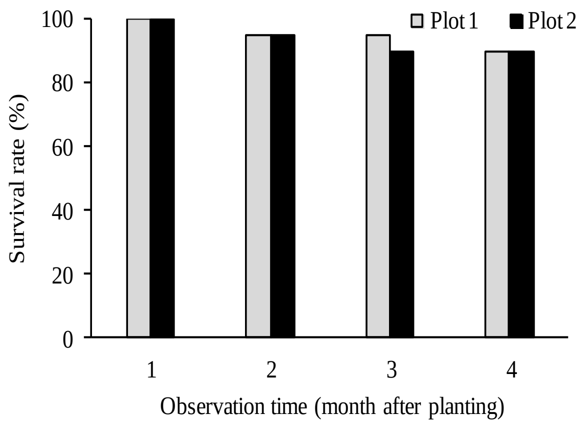

Figure 2. Survival rate of sengon in agroforestry system on the two different slopes

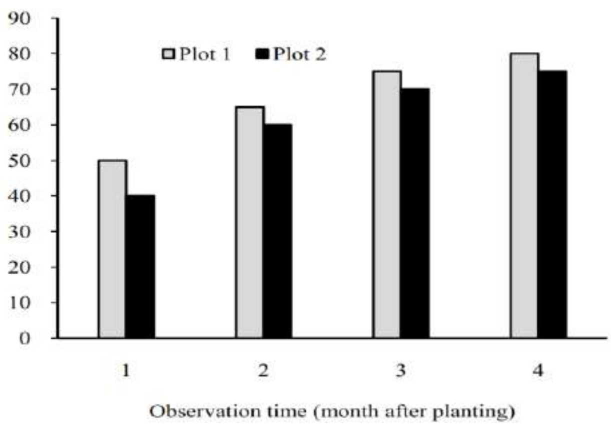

Figure 3. Ground coverage of peanut plants in agroforestry system on the two different slopes

Table 3. Qualitative evaluation of sengon dan peanut growth on the two different slope conditions

Plant species	Plot 1				Plot 2			
	Month				Month			
	1	2	3	4	1	2	3	4
Sengon	Fair	Good	Good	Good	Fair	Fair	Good	Good
Peanut	Fair	Good	Good	Good	Fair	Fair	Good	Good

Note: Plot 1 = experimental plot with 15-25% slope; Plot 2 = experimental plot with 25-40% slope located in the Education Forest of Forestry Faculty, Mulawarman University, Samarinda, Indonesia.

Table 4. Sengon stem diameter increment (mm) on the two different slopes.

Tree number	Plot 1					Plot 2				
	D_0	d_1	d_2	d_3	d_4	D_0	d_1	d_2	d_3	d_4
1	1.32	3.26	4.88	6.80	8.05	1.57	2.08	3.03	5.31	7.55
2	1.42	2.50	4.91	7.10	8.10	1.02	2.15	3.74	6.46	8.20
3	1.12	3.68	4.82	6.50	7.95	1.17	2.31	3.09	5.53	7.35
4	1.68	3.04	4.18	6.31	7.85	1.87	2.34	4.15	5.55	7.70
5	1.59	3.25	4.47	6.97	8.10	1.66	2.71	4.43	6.88	8.05
6	1.39	3.18	4.84	6.50	8.20	1.46	3.07	4.02	5.59	7.65
7	1.20	3.08	4.36	6.94	8.05	1.13	3.23	4.12	5.27	8.10
8	2.81	2.49	3.93	6.81	8.00	1.10	3.43	4.74	5.00	7.85
9	2.11	3.01	4.26	7.00	8.70	1.13	3.70	4.74	5.62	7.60
10	1.02	2.69	4.16	7.20	9.20	1.19	3.74	4.44	5.28	7.40
11	1.66	2.32	3.68	6.24	8.40	1.12	3.66	4.87	5.75	8.40
12	1.79	2.44	3.97	6.91	8.80	1.53	3.07	4.47	5.49	8.30
13	1.59	2.38	3.89	6.06	8.50	1.00	2.84	3.12	5.05	7.90
14	1.63	2.79	4.00	6.67	8.00	1.88	2.16	4.14	4.78	7.95
15	1.52	2.61	3.90	6.57	7.90	1.68	3.93	4.53	6.17	8.20
16	1.02	2.47	3.87	6.98	8.20	1.39	3.65	4.10	6.13	8.20
Mean	1.55	2.82	4.26	6.72	8.25	1.37	3.00	4.11	5.62	7.90
SD	0.44	0.40	0.41	0.33	0.38	0.30	0.65	0.59	0.56	0.33
Annual diameter increment	24.7 mm/year =2.47 cm/year					Annual diameter increment	23.7 mm/year=2.37 cm/year			

Note: Plot 1 = experimental plot located on 15-25% slope; Plot 2 = experimental plot located on 25-40% slope located in the Education Forest of Forestry Faculty, Mulawarman University, Samarinda, Indonesia; D_0 = initial stem diameter (diameter measured in the beginning of experiment); d_1,d_2, d_3, d_4 = diameter increments in the end of first, second, third, and fourth month after planting, respectively; SD=Standard Deviation

Table 5. Sengon height increment (cm) on the two different slopes

Tree number	Plot 1					Plot 2				
	H_0	h_1	h_2	h_3	h_4	H_0	h_1	h_2	h_3	h_4
1	54	25	33	49	58	58	24	34	44	54
2	54	26	35	52	61	60	27	37	47	57
3	53	27	32	48	58	56	23	33	43	54
4	59	29	35	47	58	56	24	34	44	54
5	57	27	35	47	57	55	23	33	43	53
6	57	28	36	48	59	57	25	35	45	55
7	58	29	39	50	61	56	25	35	45	56
8	59	28	35	49	58	55	24	34	44	54
9	61	31	43	54	60	57	26	36	46	56
10	56	29	38	49	56	56	23	33	43	53
11	55	27	37	43	57	54	22	32	42	52
12	56	29	32	47	60	55	25	36	46	57
13	57	28	33	49	60	56	26	36	46	56
14	54	25	36	48	58	55	24	34	44	54
15	60	33	42	50	57	54	22	32	42	53
16	60	34	46	51	60	59	27	36	46	57
Mean	57	28.44	36.69	48.81	58.60	56	24.38	34.38	44.38	54.70
SD	2.47	2.53	4.05	2.46	1.54	1.68	1.59	1.54	1.54	1.62
Annual height increment	175.8 mm/year=17.58 cm/year					Annual height increment	164.1 mm/year=16.41 cm/year			

Note: Plot 1 = experimental plot with 15-25% slope; Plot 2 = experimental plot with 25-40% slope located in the Education Forest of Forestry Faculty, Mulawarman University, Samarinda, Indonesia; H_0 = initial tree height (diameter measured in the beginning of experiment); h_1,h_2, h_3, h_4 = height increments in the end of first, second, third, and fourth month after planting, respectively; SD=Standard Deviation

Our data indicated that there were increases in diameter and height increments of sengon from month to month. These increases are presumably due to: (i) additional supply of organic matters contributed by the falling leaves of the peanut plants grown in between the sengon trees, (ii) the effect of NPK fertilizer application that served to fulfill the nutrient requirement of the plants for better growth quality and production, and (iii) the inherent fast-growing nature of the sengon trees. NPK fertilizer application in particular adequately supplies nitrogen for vigorous sengon growth. In addition, the fertilizers will improve soil structure by providing space for gas and water.

Sengon trees grown on the steep slope (Plot 2) show lower diameter and height increments compared with the trees on the slightly steep slope (Plot 1) (Table 2 and 3). This result indicates that slope gradient affects plant growth parameter, in particular, stem diameter and plant height. Kartasapoetra et al. (2000) stated that slope gradient determines soil fertility of a land. A land with relatively steeper slope is highly prone to soil erosion and nutrient leaching compared with a land with a less steep slope. The effect of slope steepness is also evident in the growth of the groundcover crop, the peanut plant. Ground coverage of the peanuts on the steep plot was lower than that of the peanuts on the slightly steep ground (Figure 2). The peanut plants seem to indirectly affect on the diameter and height growth of the sengon trees. It is through the decomposition of fallen leaves contributed for an extra source of organic materials for the growth of the sengon trees. Indeed, our chemical analysis indicated that there was an increase in soil nutrient content (C organic, N total, P, and K) and a change in soil pH (H_2O) from 4.12 at the beginning of the experiment to 4.93 at the end of the study as shown in Table 6.

Hydro-orological aspect

In this study, rainfall measurements were conducted 35 times when rain event occurred. Mean rainfall during the study was 17.41 mm/day. Table 7 shows the rainfall data, surface runoff volume, and eroded soil mass of the agroforestry system on the two different slopes. The surface runoff rate, potential erosion rate, erosion hazard index, and erosion hazard level is showed in Table 8.

Our results indicate that the steeper the slope, the higher the surface runoff volume and the erosion potential. In addition to slope gradient, the erosion rate is also determined by soil texture. Soil texture analysis indicates that the soil in this current study location is sandy loam, it is characterized by its fine texture as presented in Table 6. A finely textured soil has low water infiltration capacity. Thus, even a relatively low rainfall can generate a surface runoff on such a soil. Fine soil grains are difficult to form a stable soil structure because of the fragile cohesion between their particles, thereby highly susceptible to erosion (A'Yunin 2008).

Erosion hazard evaluation is an assessment and prediction about the scale of soil erosion and its potential danger to a particular plot of land. Erosion hazard level can indicate whether erosion is at a level that threatens or even endangers a land. We found that the potential erosion rate in Plot 1 was 20.05 ton/ha/year and in Plot 2 was 45.05 ton/ha/year. Therefore, the erosion hazard index of Plot 1 and Plot 2 were 0.80 (low) and 3.25 (moderate), respectively (Table 8). With a soil column deeper than 90 cm, the erosion rate of both Plot 1 and Plot 2 were in the range between 15-60 ton/ha/year, which are classified as low-hazard erosion according to classification system described in Table 2. This result suggests that the sengon-peanut agroforestry system is capable to suppress the erosion rate. Land rehabilitation and soil conservation by using sengon-peanut agroforestry system on different slope gradient show a positive impact on the land because the system can suppress the erosion rate up to a degree classified as low erosion hazard.

Table 6. The soil physicochemical properties in the study plot

Soil chemical properties	At the beginning of study	At the end of study
pH (H_2O)	4.12	4.93
pH (KCl)	3.37	4.26
C organic (%)	2.74	3.82
N total (%)	0.18	0.27
P_2O_5 (ppm)	19.59	23.51
K_2O (ppm)	103.11	114.07
Texture	Sandy Loam (SL)	Sandy Loam (SL)

Table 7. Rainfall, surface runoff volume, and eroded soil mass of agroforestry system on two different slopes

Rain event	Rainfall (mm)	Surface runoff (l)		Eroded soil mass (g)	
		Plot 1	Plot 2	Plot 1	Plot 2
1	24.38	17.55	32.52	985.82	1943.54
2	5.97	19.58	28.15	220.32	236.19
3	14.43	11.13	28.23	137.98	245.69
4	55.23	20.47	32.56	2985.70	9368.87
5	12.69	19.93	38.15	327.34	648.06
6	42.30	19.08	38.15	2074.65	3121.26
7	26.37	19.08	39.68	840.85	1020.41
8	6.72	18.31	36.24	251.80	334.78
9	8.46	16.79	38.15	775.23	977.68
10	36.33	19.84	37.64	1139.95	1675.59
11	8.96	18.88	28.61	477.01	524.58
12	14.18	16.79	34.34	327.34	927.07
13	13.44	13.59	21.94	288.04	518.85
14	13.68	19.01	39.17	477.78	784.38
15	2.99	3.12	4.39	36.50	45.91
16	2.49	1.72	1.21	14.94	15.74
17	17.42	20.28	33.57	372.10	690.79
18	19.66	15.90	36.12	773.19	1186.24
19	29.86	23.14	35.61	912.57	1111.97
20	8.71	15.45	37.13	128.19	221.78
21	38.81	19.84	35.61	838.56	1633.88
22	7.71	16.02	30.20	167.67	340.18
23	17.17	18.88	37.64	935.84	1337.83
24	26.87	20.67	35.61	751.10	852.55
25	2.74	5.53	7.44	48.64	59.90
26	2.74	2.29	4.83	16.79	25.18
27	2.74	2.43	3.72	17.84	20.22
28	3.98	1.53	2.48	10.94	18.82
29	5.47	11.57	24.70	160.23	330.48
30	3.73	2.67	3.77	18.60	35.48
31	15.43	11.16	22.32	127.30	177.40
32	43.29	18.31	38.15	339.54	358.11
33	18.66	3.17	5.02	20.70	45.91
34	45.28	24.04	39.17	562.60	574.81
35	10.45	23.14	35.61	210.78	245.18
Total	609.34	510.90	947.83	17774.42	31655.32
Mean	17.41	14.60	27.08	507.84	904.44

Note: Plot 1 = experimental plot with 15-25% slope; Plot 2 = experimental plot with 25-40% slope located in the Education Forest of Forestry Faculty, Mulawarman University, Samarinda, Indonesia

Table 8. Surface runoff rate, potential erosion rate, erosion hazard index, and erosion hazard level of agroforestry system on two different slopes

Slope gradient	Surface runoff rate (m^3/ha/year)	Potential erosion rate (ton/ha/year)	Tolerable erosion rate (ton/ha/year)	Erosion hazard index	Erosion hazard level
Plot 1	794.55	20.05	25 *)	0.80 (Low)	Low
Plot 2	846.61	45.50	25 *)	3.25 (Moderate)	Low

Note: Plot 1 = experimental plot with 15-25% slope; Plot 2 = experimental plot with 25-40% slope located in the Education Forest of Forestry Faculty, Mulawarman University, Samarinda, Indonesia. *) Soil depth based on soil profile made at research site, i.e.,> 100 cm. In general, the tolerable erosion rate for hilly or sloping land is 25 ton/ha/year (Rahim 1995)

The vegetative conservation of a degraded land by using agroforestry system primarily consists of three essential benefits: (i) mitigation of surface runoff and erosion, (ii) suppression and reduction of raindrops impact on the soil surface, and (iii) recovery and improvement of degraded land into a productive land (Kartasapoetra et al. 2000). Our study shows that sengon-peanut agroforestry is suitable to be implemented for rehabilitation and soil conservation of degraded land with different slope conditions. We hope that the result of this research can be applied and become a reference for all the stakeholders, including private parties and the government, especially Ministry of Environment and Forestry and Ministry of Agriculture of the Republic of Indonesia.

ACKNOWLEDGEMENTS

We express our most profound gratitude and appreciation to the Indonesian Ministry of Research, Technology and Higher Education (Kemenristek Dikti RI) for financial support through *Hibah Penelitian Produk Terapan*.

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