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Rehabilitation of critical land by Implementing complex agroforestry at the prioritized subwatersheds in the Muria Region

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ABSTRACT

The prioritized subwatersheds are comprised of seven subwatersheds that have been declared critical within the 52 subwatersheds in the Muria Mountains. An area of approximately 11,000 ha, the topography of the prioritized subwatersheds is wavy—the typical slope ranges from 25 to 45%—and susceptible to erosion. The purpose of this research was to evaluate agroforestry cropping patterns to support soil conservation and reclamation on critical lands. This study is a quantitative description of research conducted through survey. The results show that most of the researched area has Inceptisols soil type with sandy, clay, and loam textures. The nitrogen, phosphate, potassium, C-organic, and organic matter contents are relatively low while the vegetation Diversity Index is categorized as medium. Sengon trees dominate in the prioritized subwatersheds area, followed by mahogany, coffee, and teak with average Importance Values of 89.57, 60.24, 78.40, and 21.03, respectively. This research shows that an agroforestry system comprised of sengon trees and coffee is ideally applied in the prioritized subwatersheds. Coffee requires shade and reduces rain-induced erosion; sengon trees function as a shade while at the same time contributing to the soil as a source of nutrients. During rains, this combined agroforestry system is able to control surface runoff and soil erosion. A sengon/coffee-tree based agroforestry system is ecologically friendly and appropriate for development in the prioritized subwatersheds.

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1. Introduction

Critical land is land that has suffered damage causing the loss or reduction in function. Critical land is widely found throughout Indonesian territories, especially in Java where 15% of the critical land in Indonesia—an area of 2,128,680 ha—is located (Hariyanto et al., 2015). The Muria mountain region spans three regencies in Central Java—Kudus, Pati, and Jepara—and contains 52 subwatersheds; seven of these subwatersheds are in critical condition where the loss or reduction in function is caused by land use with inadequate attention to soil conservation techniques leading to erosion, landslides, nutrient loss, etc. This loss or reduction in function affects soil fertility, water quality, and the environment. Grouped, the seven critical subwatersheds are the prioritized subwatersheds. The prioritized subwatersheds cover an area of 10,989.98 ha and experience average precipitation of 1,631-3,924 mm year^{-1}. Its critical land status was determined by the "heavy" erosion rate of 180-480 tons ha^{-1} year^{-1} (Hendro, Nadhi, Budiastuti, & Purnomo, 2014). The rate of erosion significantly influences land productivity; degradation reduces the function of land and disrupts productivity.

So far, the people in the prioritized subwatersheds are largely unaware of this critical land status and the need for land conservation efforts because community incomes from the forestry and plantation sectors are relatively high; sengon (*Paraserianthes falcataria*) and robusta coffee (*Coffea* sp.) produce an annual income of hundreds of millions of rupiah (Hendro et al., 2014).

Critical land is unproductive land and requires special treatment to fulfill its designation as agricultural land. Land productivity is primarily determined by soil fertility, geomorphology, and type of land use; production sustainability is determined by the synergistic performance of these components (Kusratmoko, Dayanti, & Supriatna, 2017). Critical land affects the sustainability of agricultural productivity. Misapplied land use can reduce ecological function, hydrology, and water quality. Ecological function decreases if the interaction between land components is disturbed (Budiastuti, 2016). This has a direct effect on the performance of both hydrological functions and water quality. Land use decisions tend to be made by short-term monetary interests that do not take a long view of land use productivity; as long as the land has not yet shown a decline in productivity, conservation will not be a priority, and exploitation will continue.

The land carrying capacity is determined by the compensatory mechanisms among five components—atmosphere, biosphere, pedosphere, hydrosphere, and anthroposphere. These components together contribute to land use potential and productivity (Notohadiprawiro, 2006). Land is declared critical if the interaction of these five components is disturbed, thereby reducing or eliminating land productivity or actual benefits. Land carrying capacity can be improved through the application of technology in the form of various soil and water conservation treatments (Arham, Sjaf, & Darusman, 2019). In the case of the prioritized subwatersheds, land degradation—as seen from the rate of erosion—can be corrected through vegetative methods, that is, employing vegetation as a barrier to additional erosion (Purnomo, Sulistyo, Budiastuti, & Supriyadi, 2012). Currently, sengon is cultivated by local people in monoculture and without considering the erosion implications of planting distances. As a result, the canopy is light and sparse (Susanto & Baskorowati, 2018). This causes unhindered rainwater to strike the ground with high impact, dispersing precious soil particles that are then quickly carried away by surface runoff (Budiastuti & Sumani, 2010).

Soil and water conservation efforts have been carried out in subwatersheds with vegetation-based techniques by implementing a cropping system that combines trees with agricultural crops—an agroforestry system (Gao et al., 2013; Hani & Geraldine, 2018). Research on agroforestry shows that the combination of tree canopy and agricultural crops can reduce the erosive effect of rainwater. Rainwater behavior follows the law of earth's gravity, and the highest layer of crop canopy in the agroforestry system is the first impediment to rainwater velocity. Research on the behavior of rainwater in tree canopies shows that the movement of rainwater closely correlates with crevices formed in the canopy system; the wider the gaps in the canopy, the faster rainwater reaches the soil surface; as a result, the density of the canopy acts as a regulator of rainwater behavior (Budiastuti & Sumani, 2010; Budiastuti, 2016; Purnomo et al., 2012). Canopy gaps are determined by the tree branching systems. Crop variation using trees to increase high canopy layers and plants at lower levels hampers the speed of rainwater, reducing the impact force and erosive effects when the water reaches a ground level (Budiastuti & Sumani, 2010; Purnomo et al., 2012).

Besides the condition of the canopy covering, the physiography of critical land—slope as a determinant of surface water flow velocity—should also be assessed. In the Muria region, land slopes range from 15–25%, and in places with relatively steep slopes, the soil is very vulnerable to erosion and landslides. This area is intensively used for crop cultivation without regard to soil and water conservation considerations. As a result, the land becomes increasingly critical. The limited area of arable land requires local farmers to cultivate degraded land; therefore, an appropriate and simple strategy is needed to avoid further damage and repair already-damaged land. Agroforestry increases soil fertility, supports biodiversity conservation, and promotes carbon storage in agroecosystems (George, Harper, Hobbs, & Tibbett, 2012), making it an excellent tool in the management, repair, and prevention of critical land (Cacho, 2001).

The problem of critical land in the prioritized subwatersheds requires an integrated approach between the components of soil, water, vegetation, and cropping systems. Over-reliance on income solely derived from sengon yields promotes land degradation, thus rendering productivity levels unsustainable. The purpose of this research is to evaluate agroforestry cropping patterns to promote soil conservation on critical land. Further information is needed in order to determine effective planting systems to curb the rate of erosion, balancing the condition of natural resources against needed benefits for local communities.

2. Materials and Method

This study was conducted in the prioritized subwatersheds—seven of 52 subwatersheds in the Muria mountains. These seven subwatersheds are considered critical land and are located in three regencies—Kudus, Pati, and Jepara—in Central Java, Indonesia. They lie between 100-1600 m above sea level and are located between 110°42'03"-110°01'57"E and 6°24'25"-6°47'15"S. The average of precipitation in these areas is 1,631-3,924 mm year^{-1}, and the daily temperature is 27-30°C. The prioritized subwatersheds, with a combined area of 10,989.98 ha, is a part of a four-watershed area in the Muria mountains (Figure 1).

This research is a quantitative descriptive survey and purposive sampling based on agroforestry considerations. The human populations of this study are the seven villages located within the prioritized subwatersheds. Soil samples were collected from each of the seven subwatersheds in a composite. The parameters of this study include total nitrogen (N) (Kjeldahl method), available phosphorous (P+ (Olsen method), cation exchange capacity (CEC) (extraction method with NH_4OH), soil organic carbon (SOC) and soil organic matter (SOM) (Walkley and Black method), and soil pH (glass-electrode method). Purposive sampling of vegetation was also based on agroforestry considerations. Sampling and observations of vegetation populations were made in the same locations as the soil sampling. There are two variables in this study: dependent variables—

Importance Value, Diversity Index, dominance and soil fertility—and independent variables—climate data, soil properties, tree species, tree frequency, tree density, and tree coverage. Vegetation data were obtained through the transect method: Several transect lines were drawn along 20–50-meter intervals (depending on field conditions). The sample points on each transect were set at 3–5 meters. Each sample point was divided into quadrants (1-4) and vegetation data were obtained from each quadrant by calculating the Important Value Index—the sum of relative density, relative frequency, and relative closure in percentages (%). The Diversity Index was calculated using the Shannon-Wienner formula as follows:

$$H' = -\sum \frac{ni}{N} in \frac{ni}{N} \qquad (1)$$

Where:
H' = diversity index
ni = the sum of each i type
N = total number (overall) of individuals

The results of the Importance Value Index and the Diversity Index were used to describe the vegetation diversity in each village; soil properties were used to determine soil fertility; and tree variation and tree suitability were used to determine the role of trees in the interception of raindrops. Research data were analyzed by descriptive method.

3. Results

3.1. Overview of the prioritized subwatersheds

Land cover in the seven prioritized subwatersheds consists of wood, fruit, and seed-producing tree stands (Table 1) which are cultivated in groups so that the open areas are relatively wide. The prioritized subwatersheds have high rainfall levels (1,631-3,924 mm year^{-1}) and irregular planting patterns. Soil types and textures consist of Inceptisol, sandy clay, loam to clay, and loam. Slopes ranged from flat to very steep.

3.2. Soil properties

Soil properties are shown in Table 2. Seven soil samples were taken from seven villages within the seven prioritized subwatersheds by composite method. The nitrogen contents of the samples from the villages of Menawan, Ternadi, and Bungu were categorized as low (0.20-0.21%), while the samples from Plukar, Situluhur, Jrahi, and Tempur villages were categorized as moderate (0.24-0.31%). The highest level of phosphate (P) was found in the village of Plukar (11.14 ppm), while the phosphate values from the other prioritized subwatersheds were relatively low. Potassium (K) was quite low in all of the prioritized subwatersheds.

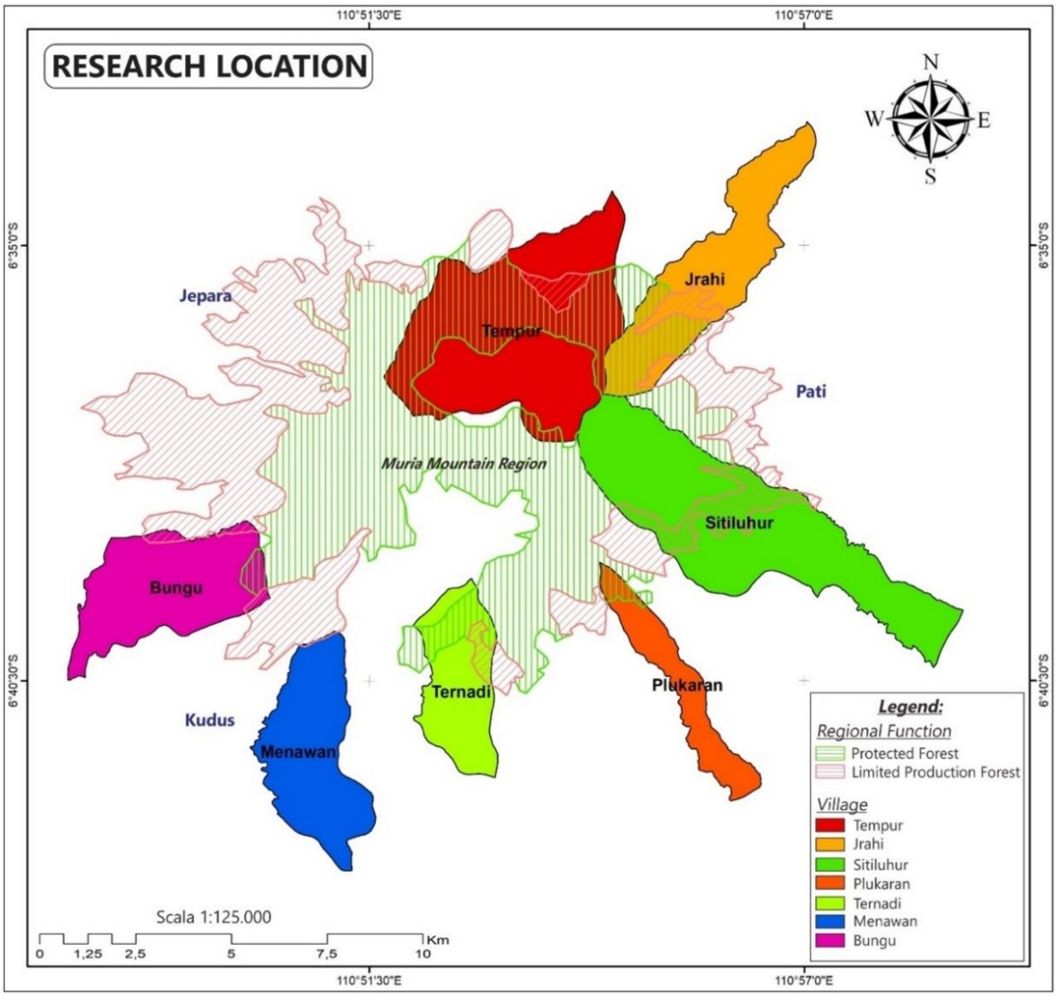

Figure 1. The location map showing the villages and the prioritized subwatersheds.

Table 1. Description of the seven prioritized subwatersheds; annual rainfall 1,631–3,924 mm year^{-1} (Source: Primary Data, 2017)

No	**Name of Village**	**Soil Type and Texture**	**Kinds of Tree**	**Land Slope**
1	Menawan (Gebog District, Kudus Regency, Srep Subwatershed, Serang Watershed)	Inceptisol Sandy clay loam to clay loam	Sengon (*Parasienthes falcataria),* Teak (*Tectona grandis*), Weru (*Albizia procera*), Mahogany (*Swietenia mahagoni*), Clove (*Syzygium aromaticum*), Coffee (*Coffea sp*)	Flat–very steep (15–45%)
2	Ternadi (Ternadi District, Kudus Regency, Piji Subwatershed, Juwana Watershed)	Inceptisol Sandy clay loam to clay loam	Sengon (*parasienthes falcataria*), Mahogany (*Swietenia mahagoni*), Kapok (*Ceiba pentandra*), Glirisidae (*Gliricidia sepium)*	Slope–very steep (25–45%)
3	Plukaran (Gembong District, Pati Regency, Sani Subwatershed, Juwana Watershed)	Inceptisol Sandy clay loam to clay loam	Sengon (*Parasienthes falcataria*), Teak (*Tectona grandis*), Coffee (*Coffea sp*), Avocado (*Persea Americana*), Pamelo oranges (*Citrus grandis*)	Flat – very steep (15–45%)
4	Sitiluhur (Gembong District, Pati Regency, Gungwedi Subwatershed, Juwana Watershed)	Inceptisol Sandy clay loam to clay loam	Sengon (*Parasienthes falcataria*), Teak (*Tectona grandis*), Coffee (*Coffea sp*), Avocado (*Persea Americana*), Pamelo oranges (*Citrus grandis*)	Flat–very steep (15–45%)
5	Jrahi (Gunungwungkal District, Pati Regency, Tayu Subwatershed, Tayu Watershed)	Inceptisol Sandy clay loam to clay loam	Sengon (*Parasienthes falcataria*), Glirisidae (*Gliricidia sepium*), Kaliandra (*Calliandra calothyrsus*), Bamboo (*Bambusa vulgaris*), Suren (*Toona sureni*)	Slope–very steep (25–45%)
6	Tempur (Keling District, Jepara Regency, Gelis Subwatershed, Wiso Gelis Watershed)	Inceptisol Sandy clay loam to clay loam	Sengon (*Parasienthes falcataria*), Teak (*Tectona grandis*), Weru (*Albizia procera*) Mahogany (*Swietenia mahagoni*), Bamboo (*Bambusa vulgaris*), Glirisidae (*Gliricidia sepium*), Kaliandra (*Calliandra calothyrsus*), African wood (*Maesopsis eminii*), Kapok (*Ceiba pentandra*)	Flat–very steep (15–45%)
7	Bungu (Mayong District, Jepara Regency, Mayong Sub Watershed, Serang Watershed)	Inceptisol Sandy clay loam to clay loam	Sengon (*Parasienthes falcataria*), Teak (*Tectona grandis*), Mahogany (*Swietenia mahagoni*), Kapok (*Ceiba pentandra*)	Slope–very steep (25–45%)

Table 2. Results of soil analysis in the seven prioritized subwatersheds.

		Soil Analysis								
No	**Name of Village**	**N**	**P**	**K**	**C-Org**	**OM**	**pH**	**Texture**		
		%	ppm	me %	%	%		% Silt	% Clay	% Sand
1	Menawan	0.21	9.00	0.26	2.05	3.53	5.17	42.88	21.06	36.06
2	Ternadi	0.20	4.71	0.32	1.89	3.26	5.24	30.76	40.72	28.52
3	Plukaran	0.28	11.14	0.31	2.38	4.10	5.47	31.16	39.81	29.03
4	Situluhur	0.31	3.63	0.30	1.09	1.88	5.59	34.83	42.88	22.29
5	Jrahi	0.24	8.19	0.27	1.13	1.94	5.18	43.39	29.43	27.18
6	Tempur	0.24	5.98	0.34	2.01	3.47	6.04	34.62	27.41	37.97
7	Bungu	0.20	3.74	0.27	2.23	3.85	4.63	46.43	28.85	24.72

Notes: N = Nitrogen, P = Phosphate, K = Potassium, OM = Organic Matter, C-Org = C organic

Table 3. The average importance value of tree stands in the seven prioritized subwatersheds.

Species	**Importance value/Sampling location**							
	Menawan	**Ternadi**	**Plukaran**	**Sitiluhur**	**Jrahi**	**Tempur**	**Bungu**	**Average Importance Value**
Sengon (*Paraserienthes falcataria)*	46.95	74.30	88.88	81.80	106.46	50.75	87.06	76.60
Mahogany *(Swietenia mahagoni L. Jacq).*	51.37	5.72	67.42	21.31	45.24	10.38	75.81	39.60
Teak *(Tectona grandis)*	37.70	11.37	45.68	62.30	40.97	41.90	26.40	38.04
Coffee *(Coffea sp)*	8.31	92.08	61.91	46.90	66.22	22.74	74.72	53.26

Table 4. The number of sengon tree stands in the seven prioritized subwatersheds.

Species	**Number of Standing/Sampling location**						
	Menawan	**Ternadi**	**Plukaran**	**Sitiluhur**	**Jrahi**	**Tempur**	**Bungu**
Sengon (*Parasienthes falcataria*)	33	29	57	55	49	21	77
Mahogany (*Swietania mahagoni*)	44	1	9	13	22	3	39
Teak (*Tectona grandis*)	32	2	15	37	14	2	12
Coffee Robusta (*Coffea sp*)	6	165	46	3	46	71	66

3.3. Land cover and agroforestry

The prioritized subwatersheds landscape conditions have wavy topography (average slope ranges from 25 to 45%) and sandy clay loam, so they are susceptible to high rainfall. The classification of vegetation types shows that there has been a decrease in vegetation diversity. The access road to the Subwatersheds is very easy and encourages the community to use forest products, in turn, decreasing vegetation diversity.

The characteristics of the tree stand in the subwatersheds were included in this study. Based on surveys in the seven sample villages, with moderate criteria, the stand Diversity Index results were as follows: Menawan – 2.490, Ternadi – 1.647, Plukar – 1.933, Sitiluhur – 2.293, Jrahi – 2.209, Tempur – 2.027, Bungu – 1.988. If the stand has a Diversity Index greater than 3 (H' > 3) is considered high and more resistant to disturbance. The Diversity Index and Importance Value of vegetation communities in the prioritized subwatersheds indicate the variety and role of tree stand with low to moderate criteria. Average Importance Value and number of tree stands are presented in Table 3 and Table 4.

4. Discussion

The types of vegetation in the seven villages in the prioritized subwatersheds are consistently based on the same soil characteristics, including relatively low levels of macroelements (N, P, K, C) (see Table 1 and 2). The nitrogen (N) content in the samples from the villages of Menawan, Ternadi, and Bungu are low at 0.20-0.21%, while levels from the other village samples, Plukar, Situluhur, Jrahi, and Tempur, are moderate. Low nitrogen is caused by incomplete litter decomposition. Sengon grows and produces litter—leaves and twigs—that contribute nitrogen, organic matter, and various minerals to the surface layer of the soil (Khalif, Utami, & Kusuma, 2014). This legume-type plant is able to fix nitrogen levels and increase soil fertility, but because much of the litter and nutrients are stripped away by surface runoff during rains, its final contribution of nitrogen to the soil is significantly diminished.

The highest phosphate value is found in the village of Plukar with a value of 11.14 ppm, while the phosphate content of the soil in the other prioritized subwatersheds areas is relatively low. Phosphorus (P) is found in organic matter and humus. It is derived through the process of mineralization involving soil organisms. Microbial activity is strongly influenced by soil moisture and temperature (Putri, 2018). Part of the critical land designation in the prioritized subwatersheds can be attributed to the relatively low phosphorus content is caused by the low soil moisture and higher temperatures, thus stunting the development of microorganisms. Increased soil temperature not only reduces soil microorganisms, but it also causes soil carbon loss (Baah-Acheamfour, Carlyle, Bork, & Chang, 2020).

Potassium (K) levels in the prioritized subwatersheds are quite low as well. The availability of potassium is determined by the cation exchange capacity (CEC). The soil texture in the study area is dominated by sandy clay loam; where clay content is relatively low, the cation exchange less intense (Putri, Utami, & Kurniawan, 2019). Land with a high cation exchange capacity has the ability to store and provide greater potassium levels and vice versa; soil with a low CEC has a limited capacity to store and provide organic carbon (C-Org) low (Winarso, 2005).

The C-Org content levels were relatively low in the prioritized subwatersheds. Carbon is a food source of soil microorganisms, so the presence of C-Org in the soil improves microorganism activity and hastens the process of soil decomposition and reactions that require the help of microorganisms, such as phosphorous dissolution, and nitrogen fixation. Low carbon availability stifles the performance of microorganisms and reduces soil quality (Amir, Sari, Hiola, & Jumadi, 2012).

Based on the results of this study, the soil in Plukar Village shows the best soil quality based on chemical characteristics (Table 2). This finding is supported by the diversity in types of trees found in the village, including sengon (*Parasienthes falcataria*), teak (*Tectona grandis*), coffee (*Coffea* sp.), avocado (*Persea Americana*), and pomelo oranges (*Citrus grandis*). Agroforestry farming systems increase C-Org in soil, and tree species in agroforestry affect the rate of soil carbon sequestration (Feliciano, Ledo, Hillier, & Nayak, 2018). Carbon in the soil affects microorganisms activity and, in turn, the decomposition of organic matter.

Plant diversification in agroforestry systems can increase soil fertility, control erosion, and preserve biodiversity (Bishaw, Neufeldt, & Mowo, 2013), and trees can modify microclimates and hydrological processes that affect water balance, such as transpiration, runoff generation, infiltration, groundwater recharge, preferential flow, and lateral flow (Charbonnier et al., 2013; Tobella et al., 2014; Benegas et al., 2014).

Land cover is evaluated by the level of diversity in vegetation, and it is a significant determinant of ecosystem stability. The greater the diversity of vegetation, the more resilient an ecosystem is in the face of disturbance (Indrajaya, 2013) The Diversity Index at the study sites shows there is moderate diversity; the number and variety species of trees are sufficient to support a stable ecosystem, but leave the areas relatively vulnerable to disturbance maintained (Budiastuti et al., 2018). The Diversity Index and Importance Values of vegetation communities in the prioritized subwatersheds show the diversity and role of tree stand with low to moderate criteria. Importance Value reflects the role or influence of a species in maintaining ecosystem stability. The importance of a tree is given a value between 0-300; a value less than 150 indicates that the tree has a lesser role in maintaining ecosystem stability (Wratten & Fry, 1980). The importance values of trees evaluated in the prioritized subwatersheds range between 38.04-76.60 with the highest found in sengon (Parasienthes falcataria) and the lowest found in teak (*Tectona grandis*) (Table 3). None of the trees have importance values above 100, which means that the role of each tree is relatively small in maintaining ecosystem stability.

In the context of soil conservation, trees function to control the speed of rain as it falls through the canopy via the branch-leaf system. Different trees create different canopy gaps that ultimately determine the effect of rainwater at the ground level (Hani & Geraldine, 2018; Budiastuti, 2016). Rainwater moves quickly as it passes through a wide canopy gap and slower though narrower gaps. The speed of falling rainwater affects the stability of the surface. An open area or minimal land cover allows an increase in disturbance to the ground surface and greater surface runoff. Research on this proves that low diversity in production forests and yards—i.e. teak, pine, damar, cocoa—does not produce critical land if supported by high canopy density (Budiastuti et al., 2018).

Most of the planted areas in the prioritized subwatersheds areas produce timber, fruit, and seeds on relatively steep slopes (25% to 45%) with mixed cropping patterns leaving certain areas uncovered by vegetation. Based on this and the high rainfall intensity (1,631-3,924 mm year^{-1}), the prioritized subwatersheds areas are prone to nutrient leaching due to erosion and surface runoff. The change in the tree stand compositions from heterogenous to mostly homogenous (primarily sengon, *Parasienthes falcataria*) reduced the Diversity Index to low to moderate criteria (H' < 3). This decrease in diversity was the primary reason land the prioritized subwatersheds was classified as critical land. When more diverse, the tree stands in the prioritized subwatersheds were better able to mitigate the effects of the rain that now disperses soil particles and washes away much-needed nutrients. An increase in stand diversity and the resultant increase in stand canopy density would mediate the force of wind and rain and protect soil quality (Budiastuti, 2016).

Land criticality reflects a relatively low level of ecosystem stability as indicated by high erosion rates (180-480 tons ha^{-1} year^{-1}) (Hendro et al., 2014). Continuous soil particle dispersion can reduce soil porosity and increase surface runoff (Kusratmoko et al., 2017). Therefore, critical land management plans are based on cropping models that are naturally inclined to control erosion and surface runoff. The prioritized subwatersheds area is dominated by sengon—a tree with small leaves that fall out easily. Revised cropping patterns have been developed to control surface runoff by cultivating agricultural crops to be managed under sengon stands (sengon-based agroforestry).

Coffee is the most ideal type of agricultural crop to integrate into a sengon-based agroforestry system. The weakness of the sengon canopy character as a rain controller is rectified by the presence of coffee as a second canopy layer to further decrease the force of rain before it reaches the ground surface (Budiastuti et al., 2018). Coffee contributes much-needed nitrogen to the soil, and as its growth and development require shade, it is particularly appropriate for use under sengon trees. The prioritized subwatersheds are well-placed for agroforestry development using a mixed pattern between timber-producing stands to act as shade and fruit or seed-producing stands with high economic potential.

The best solution to reduce the rate of soil erosion is to increase the potential of currently marginal land—especially critical and degraded land—through agroforestry-based land management techniques. The current stands of sengon provide plant nutrition and produce wood and coffee; they naturally mitigate the effects of rain-induced erosion while having significant economic potential. Implementation of a sengon-based agroforestry system, aside from preventing further land criticality, is expected to improve the welfare of the local community by stabilizing and increasing long-term productivity. Sengon/Coffee is an agricultural cultivation technique that supports the sustainability of the natural resources in the prioritized subwatersheds.

5. Conclusion

Sengon is the dominant wood-producing tree in the prioritized subwatersheds, and while it is useful in increasing the nitrogen content of the soil, viewed in terms of soil conservation, the tree has not met expectations. Its branching system is of limited utility in controlling the strength or speed of rainwater. Happily, the weakness of sengon as a soil conservation tree can be overcome through the simple expedient of growing coffee between and among the sengon. This sengon/coffee agroforestry crop pattern is able to control the detrimental effects of falling raindrops, and thus facilitates the rehabilitation of critical land, and the combination has the added benefit of preventing future soil degradation and increasing long-term productivity and sustainability.

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Declaration of Competing Interest

The authors declare no competing financial or personal interests that may appear and influence the work reported in this paper.

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