Site Analysis and Conservation of Gelam (*Melaleuca cajuputi*) on Peat Swamp Forest in South Kalimantan, Indonesia

Yudi Firmanul Arifin [1,2], Siti Hamidah [1,2], Yulian Firmana Arifin [3]

1) Faculty of Forestry, Lambung Mangkurat University
2) Consortium for Sustainable Tropical Forest Management, Lambung Mangkurat Univ.
3) Faculty of Engineering, Lambung Mangkurat University

Abstract
Until now the raw material of wood especially Gelam (*Melaleuca cajuputi*) for supporting the construction of housing and other infrastructures is increasingly large in Indonesia. On the Island of Borneo that partly consists of peat swamps needs Gelam very large and continuous, particularly for residential development. Ecological aspects are very important for supporting the silvicultural strategies. Aim of this study is to analyze site aspects which are very influence especially physical and chemical soil and microclimate as well. The utilization of study is to determine the silvicultural strategies for continuing production and conservation of Gelam in the future. The method was used a field survey around Gelam forest and did collecting samples and measuring there. The results showed in South Borneo the potency of Gelam is only 2,9-7,1 m3/ha and decreasing yearly. Normally Gelam with a diameter <4 cm have been cut down, as well as > 30 cm. Gelam can grow on the peat swamp forest where the soil was low pH 3.5-3.9. Most of pH of soil in these areas was influenced by phyrite (FeS2 of 0.4-2.2% and highest of Fe 90-302 ppm. C organic in the soil was included low-moderate 5.5-10.0%. Temperature and humidity around peat swamp forest areas where was found Gelam were 31-33^{o}C and 63-73% respectively. Most of areas around Gelam were grown Gelam Tikus (*Syzygium inophylla*) and some kind of shrubs.

Keywords; Gelam, potency, ecological aspects, silviculture

I. Introduction

Melaleuca cajuputi is a woody plant of the Myrtaceae where is distributed from Australia to southeastern Asia and develops pure forest at tropical swamps (Blake, 1968). This species commonly fure stands on swampy ground (Blake, 1968; Whitmore, 1984). M. cajuputi is a dominant tree species in degraded peat swamps that occur extensively in Narathiwat Province, Thailand (Suzuki and Niyomdham, 1992).

Research on site of Gelam is not yet widely done, the data obtained more than writing some text book, not the result of research published in the journal, so that reference about this plant is still very little. The lack of information on tropical lowland peat swamp ecology, evolution and conservation biology, in planning and implementation development projects as well as the absence of a comprehensive assessment of natural resource potential and values of

peat swamps (Phillips, 1998). But in terms of the importance of this plant for development, especially the development of infrastructure such as; houses, bridges, and other research on softwood will support the conservation and optimal utilization (Arifin et al., 2014).

Gelam (*Melaleuca cajuputi*) are found in peat swamp forests are affected by the tidal ebb and flow. This type of fire climax classified as pioneer species, which after forest fires will only increase seed germination, because fire can clean up litter and dormant seeds of other plant species which become competitors (Mac Kinnnon, *et al*., 1985).

Gelam spreads in Southeast Asia from the Malay Peninsula to the Maluku Islands. In Indonesia, naturally this species is found in South Sumatra, Central Sulawesi, Bali, Coastal South Kalimantan, Central Kalimantan and Irian Jaya (Samingan, 1971). In South Kalimantan it is also found in relatively dry land (the former heath forest) such as; The Sebuhur, Liang Anggang, Village Ulin Platform, and Liang area Anggang District of Bat-bati. Gelam forests are forests that are in the area of peat swamp forest with a fairly high soil acidity. Gelam forest is generally homogeneous forest, but there is also growing in freshwater.

Before Gelam cultivation is needed to analyze is suitable habitat to growing up the success of plantations. This research is designed to give a description of Gelam habitat in South Kalimantan.

II. Methods

Inventory to determine the potential and ecological conditions.

1) Observation of Gelam conducted in Batola District and Tapin District in South Kalimantan.
2) Observation began with the recognition of the existence of Gelam in the study site, which is monitored through reports and information from the local community.
3) If the information obtained indicates that the source of Gelam, then survey was done using plots of 200 x 200 m is divided into sub-sub plots with a size of 20 x 20 m. Each sampling plot was collected the soil with deepest till 20 cm.

Picture 1. The location of sample plots

III. Result and Discussion

3.1. The potency of Gelam

The use of Gelam is increasing not only for the development of construction of houses on stilts in swamp areas, but it is also used for the manufacture of boards or beams to the interior of the house, and pieces or wastes used as firewood. Most people use for firewood which is marketed in Batola and Bati-Bati. Gelam sourced from seeds generally have a relatively straight of stem and have monopodial branching shape, so that the stems are widely used for materials / wood construction. Contrary, the tree which is derived by coppices tends sympodial branching shape, so it is often used for firewood. If the stem diameter >20cm and length >4m used as carpentry (Lazuardi and Supriadi, 2000).

In the district of Batola as center of Gelam producers in South Kalimantan has the potential volume around to 2.9 to 7.1 m3 / ha. This district is bordered by Kapuas so the majority of raw materials for South Kalimantan region supported by Kapuas District.

3.2. The Habitat

3.2.1. Micro climate

Based on the measurement of microclimate data in the research sites, it seems that the three study sites have similar micro-climatic conditions. Average temperatures ranged from 31.2 to 32.6 ° C, and humidity 63-73%. M. cajuputi seeds collected in floodplains in Nathiwat Province, Thailand, were sown on quartz sand and placed in a controlled-environment room at 25-30ºC, a

photosynthetic photon flux density (PPFD) of 180 µmol $m^{-2}s^{-1}$ (Tanaka et al., 2011). This situation shows that Gelam grows in open areas and do not require shade.

Table 1. Micro climate around Gelam Forest

Parameter	Result of Measurement		
	Plot 1	Plot 2	Plot 3
Temperature (^{0}C)	31.50	31.20	32.60
Humidity (%)	68.00	73.00	63.00

Information: 1) plot 1 and plot 2 in Antarjaya Village
2) plot 3 in Teluk Tamba Village

3.2.2. Physical and Chemical Soil

Gelam (*Melaleuca cajuputi*) was found on the peat swamp forests which is influenced by tides. This species is classified as pioneer species, which after a forest fire seed germination will increase, because the fire can clean up litter and dormant seeds (Mac Kinnnon, et al., 1985). M. cajuputi grows at sites characterized by extreme change in soil moisture conditions by rainfall fluctuation (Tanaka et al., 2011). All the sites, the groundwater level could be range from deeper than 2 m below the peat soil surface during the dry season to higher than 1 m above the surface during rainy season (Yamamoshita et al., 2001)

Table 2. Texture of soil on the Gelam Forest

Parameter	**Location**			
	Plot 1	Plot2	Plot3	Plot4
Sand (%)	5.01	12.00	11.44	5.93
Dust (%)	32.65	32.91	36.22	50.46
Clay (%)	62.34	55.09	52.34	43.61

Information: 1) Plot 1,2,3 in Batola District
2) Plot 4 in Tapin District

Soil texture shows a comparison of the proportion of sand (diameter 2.00 to 0.05 mm), dust (0.005 to 0.02 mm) and clay (<0.002 mm) in the soil. The soil in the study site consist of clayey class (Table 2), with the consistency of the soil is generally very closely to wet soil category. These results indicate that clay content is higher than that of dust and sand.

Table 3. Chemical Compounds in the soil

Parameter	**Location**			
	Plot 1	Plot 2	Plot 3	Plot 4
pH	3.46	3.58	3.69	3.86
Ntot	1.23	0.90	1.21	1.29
C-organic (%)	6.55	8.14	5.51	10.02
P2O5 mg/100gr	83.38	100.46	175.11	79.49
K2O mg/100gr	10.74	10.78	21.55	22.35
Fe ppm	302.89	132.23	197.52	90.00
Pyrite (%)	0.42	2.20	0.45	0.58

Information: 1) Plot 1,2,3 in Batola District
2) Plot 4 in Tapin District

Soil reaction is controlled by the electrochemical properties of soil colloids. This term indicates the acidity and alkalinity of soil, the rank is determined by the concentration of hydrogen ions in the soil solution. Soil reaction (pH value) can affect the supply of nutrients to the plant. The soil pH at the Gelam habitat was generally very acidic reaction, with pH values ranging from 3.46 to 3.86. The low pH indicates the presence of pyrite layers of paint or clay. The pH 3.46-3.86 included potential acidic-sulfate according Taxonomic-Soil. The study area contains of pyrite ranged from 0.42 to 2.20%. The potential land is swamp land that has the potential acid sulphate soil types with pyrite content of <2% with recesses> 50 cm from the ground (Noor, 2004).

Organic carbons in swampy areas of gelam are generally high for the area having a high pile of material organic but on alluvial soil, organic carbon can be low. Result of laboratory

analysis was the organic-C levels of 5.51 to 8.14% in Batola District and about 10,20% in Tapin District, with status of C% had very low to moderate dignity.

Nitrogen is the nutrient that most often are in a state of deficiency for the plant, and is the fourth macro nutrients are important after carbon, hydrogen and oxygen. The nitrogen content in the region Barito Kuala ranged from 0.90 to 1.23%, in Batola and about 1.29% in Tapin with dignity nutrient of nitrogen from very low to low.

Conservation

For the conservation of gelams, the diameter <4cm should not be cut because these were too young and diameter >30cm not cut down and used as source of seeds, but in reality is still being done by the logging community. Generally, aged 3-5 years stand of Gelam will be harvested, so that rotation become shortly. The young of Gelam with aged 3-5 years should not be harvested because it is still young.

Gelams in South Kalimantan Province are normally formed by small to large stem diameters of 3-5cm, 10-20cm and > 20cm, this condition threatens the sustainability of Gelam. Under existing regulation in the Batola District that stem diameters of <4cm and >30cm may not be harvested for preservation purposes as mentioned before. This means that the regulations enacted there is not going well, so monitoring and strict enforcement needs to be done (Arifin *et al*., 2014).

In Hulu Sungai Selatan with partly a swamp forest and produce Gelam by Decree No. Hulu Sungai Selatan 500/04 / Ekobang January 5, 2009 clearly states that the moratorium / termination / temporary ban logging in the forests of both people and other forest areas (Anonimous, 2009). This situation shows that the gelam harvested in the district of Hulu Sungai Selatan is illegal. However, in reality the field is still outstanding gelam obtained from this region (Arifin *et al*., 2014). Gelam logging originating from South Kalimantan region is only used for local needs in the province. Shortage of supply of gelam for South Kalimantan region mostly from Kapuas Region.

Discussion

Microclimate particularly temperature is important factor should be considered for cultivation. *M. cajuputi* grows very well in South Kalimantan with temperature of 31.20-

31.60ºC and humidity of 63-73%. It seeds collected in floodplains in Thailand at 25-30ºC (Tanaka et al., 2011).

M. cajuputi can survive submergence and commonly known in herbaceous plants with amphibious characteristics. It can grow in South Kalimantan with acidic (pH 3.46-3.86) and phyrite (0.42-2.20%). The water draining from a peat swamp is acidic (pH 3.00-4.50) low in inorganic ions and oxygens, and has high concentrations of humid acid that gives it a characteristic "black water" appearance (Bennet and Gobek, 1992). Some herbaceous plants grow temporarily while submerged, owing to fluctuations in the water level, subsequently grow normally under aerobic conditions; these are referred to as "amphibious" plants (He et al., 1999; Nabben et al., 1999).Seed dispersal of M. cajuputi is induced by field fire during the dry season, the seeds will germinate immediately at moist conditions by increase in rainfall, and they can survive submergence for 3 months or more during the rainy season (Yamanoshita, 2001).

A few researchers have studied the growth responses of woody plants under submergence. Lockhart (1996) reported that *M. quinquenervia* survived for 26 weeks and developed heterophylly under submergence. Salter et al. (2007) reported that *M. ercifolia* stopped growing under submergence. Parolin (2009) reported that *Astrocaryum jauari* in Amazonian swamps stopped growing but survived under water at depths exceeding 10 m for 300 days.

The management system of *M. cajuputi* should be made to reduce the damaged of regeneration. The limit diameter should be controlled so sustainability can be kept. The diameter <4cm should not be cut because these were too young and diameter >30cm not cut down and used as source of seeds.

IV. Conclusion

Conclusions from the study can be summarized as follows:

1. Potential volume of Gelam in South Kalimantan Province is relatively small between 2.9-7.1m3 / ha, originated from Central Kalimantan Province especially Kapuas District.
2. The soil pH of Gelam habitat is very acidic reaction ranging from 3.46 to 3.86. The low pH indicates the presence of pyrite layers of paint or clay.
3. Management of Gelam in South Kalimantan in general is not in accordance with the regulations that threaten its sustainability.

Refrences

Anonimous, 2009. SK Bupati Hulu Sungai Selatan No. 500/04/Ekobang tanggal 5 Januari 2009.

Arifin Y., F., , Hamidah S., Arifin Y., F., 2014. The Analysis of Management and Timber Tread System of Galam (*Melaleucacajuputi*) from Peat Swamp Forest in South Kalimantan. Journal of Wetlands Environmental Management Vol 2, No. 2, August 2014, ISSN 2354-5844.

Blake ST, 1968. A Revision of *Melaleuca leucadendron* and Its Allies (Myrtaceae). Contrib Queens Herb 1:1-114

Dephut, 2003. Budidaya Kayu Putih (*Melaleuca cajuputi*) (silviculture of kayu putih). Departemen Kehutanan, Jakarta. 29p.

He J.B., Bogemann G.M.., van de Steeg H.G., Rijnders J., Voesenek L., Blom C., 1999. Survival tactics of Ranunculus species in river floodplains. Oecologia 118:1-8

Lazuardi, D. dan Supriadi, R., 2000. Teknik Pengelolaan Hutan Gelam Rakyat di Kalimantan Selatan (management technique of gelam forest in South Kalimantan). Laporan Hasil Penelitian (report of research). Balai Teknologi Reboisasi. Departemen Kehutanan. Badan Penelitian dan Pengembangan Kehutanan dan Perkebunan Banjarbaru.unpublished.

Lockhart C.S., 1996. Aquatic heterophylly as a survival strategy in Melaleuca quinquenervia (Myrtaceae). Can J Bot 74: 243-246

Mac Kinnon, K., Hatta, G., Halim, H., and Mangalik, A., 1996. The ecology of Kalimantan (Indonesia Borneo). Periplus Editions (HK) Ltd. P130-458.

Nabben R. H. M., Blom C., Voesenek L., 1999. Resistance to complete submergence in rumex species with different life histories: the influence of plant size and light. New Phytol 144:313-321

Noor M., 2004. Lahan Rawa, Sifat dan Pengelolaan Tanah Bermasalah Sulfat Masam. PT. Raja Grafindo Persada, Jakarta.

Parolin P., 2009. Submerged in darkness: adaptation to prolonged submergence by woody species of the Amazonian floodplains. Ann Bot 103; 359-376

Phillips V. D., 1998. Peatswamp ecology and sustainable development in Borneo. Biodiversity and Conservation 7: 651-671.

Samingan, T., 1971. Tipe-tipe Vegetasi (Pengantar Dendrologi) Proyek Peningkatan /Pengembangan Perguruan Tinggi IPB, Bogor.

Salter J., Morris K.,Bailey P.C.E., Boon P.I., 2007. Interactive effects of salinity and water depth on the growth of Melaleuca ericifolia Sm. (swamp paperbark) seedlings. Aquat Bot 86:213-222

Suzuki, K., and Niyomdham, C., 1992. Phytosociological studies on tropical peat swamps: 1. Classification of vegetation at Narathiwat, Thailand. Tropics 2: 49-65.

Tanaka K., Masumori M., Yamanoshita T., Tange T., 2011. Morphological and anatomical changes of Melaleuca cajuputi under submergence. Trees (2011) 25:695-704.

Whitmore, T.C., 1984. Forest Formations: 92) The wet-land rain forest. In Tropical rain forests of the Far East. Whitmore. T.C. (ed.). 352pp. Oxford University Press. Oxford, 178-195.

Yamanoshita T., Nuyim T., Masumori M., Tange T., Kojima K., Yagi H., Sasaki S., 2001. Growth response of Melaleuca cajuputi to flooding in a tropical peat swamp. J For Res 6: 217-2019