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ABSTRACTS

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Vivi Yuskianti and Susumu Shiraishi

GENETIC DIVERSITY OF SENGON (*Falcataria moluccana* (Miq.) Barneby & J.W.Grimes) REVEALED USING SINGLE NUCLEOTIDE POLYMORPHISM (SNP) MARKERS

(KERAGAMAN GENETIK SENGON (*Falcataria moluccana* (Miq.) Barneby & J.W.Grimes) MENGGUNAKAN PENANDA SINGLE NUCLEOTIDE POLYMORPHISM (SNP))

Pengetahuan tentang keragaman genetik dan hubungan kekerabatan antara populasi merupakan hal penting bagi konservasi genetik dan program pemuliaan pohon.Tulisan ini mempelajari penggunaan penanda SNP untuk mengetahui keragaman genetik dan hubungan kekerabatan sengon. Analisa dua belas penanda Single Nucleotide Polymorphism (SNP) pada sengon di kebun benih Candiroto Jawa Tengah menunjukkan bahwa total populasi mempunyai keragaman genetik yang tinggi (He=0.359±0.128). Sengon dari Wamena mempunyai keragaman genetik tertinggi sementara sengon dari wilayah Jawa terkecil. Hasil analisa hubungan kekerabatan menunjukkan sengon terbagi dalam tiga cluster; yang pertama, sengon dari Jawa Timur dekat dengan Wamena, yang keduanya ter-cluster dengan Biak dan kemudian Pulau Makian; cluster kedua, Jawa Barat dan Jawa Tengah dengan Pulau Mindanao; dan terakhir Halmahera. Informasi hubungan kekerabatan ini dapat digunakan untuk mendukung program pemuliaan pohon dan populasi genetik sengon. Sebagai contoh untuk koleksi materi genetik sebagai bahan pembangunan kebun benih sengon selanjutnya perlu meminimalkan pengambilan materi genetik dari Jawa karena selain mempunyai keragaman genetik yang lebih rendah dari populasi lainnya, juga terindikasi mempunyai hubungan kekerabatan yang dekat dengan sengon dari Papua dan Mindanao. Sementara sengon dari Biak dan Wamena di Papua dan Halmahera di Maluku dapat secara langsung dikoleksi karena mempunyai keragaman geneitik yang tinggi dan cluster yang berbeda.

Kata kunci: Sengon (*Falcataria moluccana*), keragaman genetik, hubungan kekerabatan, penanda SNP

UDC/ODC 630*228.125

Subekti Rahayu, Sambas Basun, Agus Priyono Kartono, Agus Hikmat and Meine van Noordwijk

TREE SPECIES COMPOSITION OF 1.8 HA PLOT SAMBOJA RESEARCH FOREST: 28 YEARS AFTER INITIAL FIRE

(KOMPOSISI JENIS POHON PADA PETAK SELUAS 1,8 HA DI HUTAN PENELITIAN SAMBOJA: 28 TAHUN SETELAH KEBAKARAN PERTAMA)

Kebakaran hutan berulang berdampak besar terhadap komposisi jenis pohon. Perencanaan restorasi hutan memerlukan informasi mengenai komposisi jenis yang beregenerasi secara alami pada hutan bekas terbakar. Tulisan ini mempelajari jenis yang beregenerasi secara alami, proses regenerasi yang terjadi setelah kebakaran berulang, dan rekomendasi untuk implementasi restorasi pada hutan yang sedang beregenerasi. Pengamatan ulang terhadap petak permanen di KHDTK Samboja, Kalimantan Timur dilakukan tahun 2011. Semua pohon berdiameter di atas 10 cm pada sub-petak 10 m x 10 m dicatat, diukur DBH, dipetakan posisi koordinatnya dan diambil contoh daun untuk identifikasi tingkat jenis. Komposisi taksa, Indeks Nilai Penting dan indeks persebaran jenis dihitung. Karakter jenis berdasarkan responnya terhadap cahaya diidentifikasi. Dua puluh delapan tahun setelah kebakaran pertama, 191 jenis beregenerasi pada hutan bekas terbakar. *Macaranga gigantea*, jenis pionir tergantung pada cahaya, famili Euphorbiaceae merupakan jenis paling dominan diikuti *Vernonia arborea* dari Asteraceae. Kedua jenis tersebut memiliki pola sebaran mengelompok. Delapan jenis diidentifikasi mampu bertahan dari kebakaran yaitu: *Anthocephalus chinensis*, *Dipterocarpus cornutus*, *Diospyros borneensis*, *Eusideroxylon zwageri*, *Shorea ovalis*, *Syzygium borneensis*, *Pholidocarpus majadum* dan *Vatica umbonata* yang semuanya menyebar secara seragam. Dominasi jenis pionir yang beregenerasi setelah kebakaran dan regenerasi spesies yang mampu bertahan dari kebakaran menunjukkan bahwa kondisi hutan berada pada tahap awal suksesi. Perlindungan hutan, pemeliharaan permudaan alami, dan pemantauan spesies dominan merupakan kegiatan yang dianjurkan dalam restorasi ekologi.

Kata kunci: Kalimantan Timur, kebakaran hutan, komposisi spesies, restorasi ekologi

UDC/ODC 630*111.83

Sandhi Imam Maulana and Yohannes Wibisono

DYNAMIC PROJECTION OF CLIMATE CHANGE SCENARIOS ON ABOVEGROUND CARBON STORAGE OF TROPICAL TREES IN WEST PAPUA, INDONESIA

(PROYEKSI DINAMIS BERBAGAI SKENARIO PERUBAHAN IKLIM TERHADAP SIMPANAN KARBON DI ATAS PERMUKAAN TANAH PADA BERAGAM JENIS POHON TROPIS DI PAPUA BARAT, INDONESIA)

Melalui fotosintesis, ekosistem hutan menangkap dan menyimpan emisi karbon dalam bentuk biomassa yang paling besar dibandingkan dengan jenis vegetasi lain, dan memainkan peran yang sangat penting dalam menangani perubahan iklim. Namun demikian, peran penting tersebut secara signifikan dapat terganggu oleh perubahan temperatur dan curah hujan yang ekstrem karena penyimpanan karbon di lanskap hutan sangat terkait dengan variabel iklim tersebut. Tulisan ini mempelajari dampak gangguan iklim di masa depan pada penyimpanan karbon di atas tanah pada tiga spesies pohon tropis, yaitu *Myristica* sp., *Palaquium* sp., dan *Syzygium* sp. melalui evaluasi skenario "bagaimana jika" berbasis STELLA. Hasil penelitian menunjukkan bahwa ketika simulasi dinamis dijalankan mengikuti lima skenario perubahan iklim oleh IPCC untuk periode simulasi 200 tahun, terlihat bahwa skenario moderat, seperti B1 dan A1T, telah menyebabkan simpangan yang signifikan untuk ketiga spesies pohon tropis tersebut. Pada skenario terburuk A1F1 (kenaikan suhu 4°C ditambah dengan pengurangan 20% curah hujan), pohon dari spesies Palaquium sp. memperlihatkan tingkat penurunan tertinggi pada simpanan karbon di atas tanah dengan sekitar 17,216% kurang dari nilai normalnya. Hal ini menunjukkan bahwa umpan balik negatif dari perubahan iklim harus diperhitungkan untuk memastikan keakuratan penghitungan karbon hutan jangka panjang di bawah ketidakpastian iklim di masa depan.

Kata kunci: Perubahan iklim, simpanan karbon diatas tanah, Papua Barat, STELLA

UDC/ODC 630*861.0:721.1(5)

Gunawan G.T.P Simanjuntak Chingyang Lin

DEMAND ANALYSIS OF INDONESIAN PULPWOOD USING TRANSCENDENTAL LOGARITHMIC MODEL: A STUDY OF THE WORLD AND SELECTED ASIAN MARKETS

(ANALISIS PERMINTAAN BUBUR KERTAS INDONESIA DENGAN MENGGUNAKAN MODEL TRANSCENDENTAL LOGARITHMICH: STUDI DI DUNIA DAN BEBERAPA PASAR ASIA)

Ekspor bubur kertas Indonesia telah menunjukkan trend yang meningkat sejak era 1990an. Bersama-sama Brazil, Canada, USA, dan Chili, Indonesia menjadi satu dari lima pengekspor bubur kertas terbesar di dunia. Bubur kertas Indonesia sebagian besar diekspor ke negara-negara Asia. Tulisan ini menganalisis permintaan ekspor bubur kertas Indonesia periode 1994-2014 menggunakan model Trancendental Logarithmic (TL) dengan estimasi Seemingly Unrelated Regression (SUR). Data ekspor dari lima negara pengekspor bubur kertas terbesar di empat pasar yang berbeda (Cina, Korea, Jepang, dan dunia) dianalisis. Hasil yang ditemukan adalah sebagai berikut: pertama, logaritmik pendapatan dan second order logaritmik pendapatan berpengaruh signifikan di pasar Cina dan Korea. Kedua, secara umum elastisitas harga bubur kertas Indonesia (own-price) adalah elastis dan negatif (masing-masing -2,308, -1,06, dan -2,04 di pasar Korea, Jepang, dan dunia). Ketiga, sehubungan dengan nilai elastisitas yang positif pada harga bubur kertas negara lain (cross-price) dan juga positif pada elastisitas pendapatan (masing-masing 1,002, 1,722, dan 0,625 di pasar Cina, Korea, dan dunia), maka bubur kertas Indonesia dapat dikategorikan sebagai barang substitusi dan barang normal. Terakhir, terkait dengan nilai elastisitas harga bubur kertas Indonesia (own-price) yang negatif dan elastis, satu kebijakan yang dapat diterapkan oleh pemerintah Indonesia adalah pemberian subsidi untuk mengurangi harga bubur kertas Indonesia sebesar 10%. Subsidi dapat diimplementasikan dengan mengurangi pajak dan retribusi seperti pajak bumi dan bangunan (PBB) dan retribusi daerah. Dengan melakukan hal ini maka akan memberikan manfaat lebih banyak di pasar Korea dibandingkan dengan pasar bubur kertas lainnya. Share permintaan di pasar Korea akan meningkat dari 0,28 menjadi 0,31 dengan nilai rate of return yang tinggi (>2). Pada pasar dunia, share permintaan bubur kertas Indonesia akan meningkat dari 0,08 menjadi 0,1 dengan nilai rate of return sebesar 1,89. Oleh sebab itu, studi ini menyarankan agar pemberian subsidi dapat dilakukan pada industri bubur kertas di Indonesia.

Kata kunci : Bubur kertas, ekspor, share permintaan, transcendental logarithmic, kebijakan

UDC/ODC 630*116:911

Iis Alviya, Muhammad Zahrul Muttaqin, Elvida Yosefi Suryandari and Retno Maryani

STAKEHOLDERS' PERCEPTION ON MANAGEMENT OF UPSTREAM CILIWUNG WATERSHED: IMPLICATIONS FOR FOREST LANDSCAPE PLANNING

(PERSEPSI PARA PEMANGKU KEPENTINGAN TERKAIT PENGELOLAAN DAS CILIWUNG HULU: IMPLIKASI TERHADAP PERENCANAAN LANSEKAP HUTAN)

Hutan memiliki peranan yang sangat penting baik bagi masyarakat pedesaan maupun perkotaan. Mengakomodir berbagai persepsi para pengguna hutan terhadap praktik-praktik pemanfaatan hutan merupakan salah satu aspek yang paling penting dalam pengelolaan hutan. Tulisan ini bertujuan untuk menguraikan bagaimana persepsi para pemangku kepentingan terhadap aspek biofisik, sosial ekonomi, dan kelembagaan dalam pengelolaan lansekap hutan di DAS Ciliwung hulu. Pengumpulan data dilakukan melalui survey dengan menggali preferensi, persepsi, dan harapan-harapan pihak-pihak yang memiliki kepentingan dan juga yang terkena dampak dalam pengelolaan DAS Ciliwung hulu. Hasil studi menunjukkan bahwa menurut masyarakat DAS Ciliwung hulu aspek sosial ekonomi adalah faktor yang paling penting dalam mengelola hulu DAS Ciliwung. Di sisi lain, pemerintah baik pusat maupun daerah memiliki persepsi bahwa aspek biofisik dan kelembagaan yang lebih utama. Namun demikian, berdasarkan hasil analisis secara keseluruhan menunjukkan bahwa aspek kelembagaan merupakan prioritas utama yang harus dibenahi, diikuti oleh aspek sosial ekonomi dan aspek biofisik dalam memperbaiki pengelolaan DAS Ciliwung hulu. Upaya mengatasi aspek kelembagaan sangat diperlukan untuk meningkatkan kesadaran dan koordinasi antar pemangku kepentingan, menegakkan hukum, dan mengembangkan sistem pemantauan dalam upaya pelestarian hutan di wilayah hulu DAS. Dari aspek sosial ekonomi, upaya peningkatan mata pencaharian masyarakat di daerah hulu DAS Ciliwung sangat diperlukan melalui pembayaran jasa lingkungan. Sementara itu terkait dengan aspek biofisik, kegiatan penghijauan dan konservasi tanah dan air di DAS Ciliwung hulu perlu diprioritaskan. Dengan demikian diperlukan program yang dapat memberikan solusi berdasarkan tiga aspek utama untuk meningkatkan pengelolaan sumberdaya hutan di daerah DAS Ciliwung hulu.

Kata kunci: Pengelolaan DAS, persepsi para pemangku kepentingan, masyarakat, kelembagaan

UDC/ODC 556.332.7:630*176.2

Endang Hilmi, Cecep Kusmana, Endang Suhendang and Iskandar

CORRELATION ANALYSIS BETWEEN SEAWATER INTRUSION AND MANGROVE GREENBELT

(ANALISIS KORELASI ANTARA INTRUSI AIR LAUT DENGAN JALUR HIJAU MANGROVE)

Intrusi air laut merupakan proses masuknya air laut ke daratan. Faktor-faktor yang menyebabkan terjadinya intrusi air laut diantaranya adalah pemompaan air tawar hingga kerusakan ekosistem mangrove. Ekosistem mangrove adalah suatu ekosistem yang memiliki kemampuan untuk mengurangi proses intrusi air laut. Penelitian ini menganalisis pendugaan dan prediksi intrusi air laut, hubungan antara lebar jalur hijau mangrove dengan intrusi air laut. Analisis hubungan antara lebar jalur hijau dan intrusi air laut menggunakan suatu model persamaan. Penelitian ini dibangun dengan menggunakan pendekatan teknik sampling, analisis sistem dengan powersim, analisis korelasi, analisis matematika dengan menggunakan "trendline". Hasil dari oenelitian ini adalah (1) potensi kerapatan mangrove adalah sekitar 50 – 109 pohon/hektar. (2) hasil simulasi menunjukan laju intrusi air laut jika ada mangrove mencapai 0,20 km/tahun, tapi jika tidak ada mangrove mencapai 0,3 – 0,4 km/tahun. (3) hasil simulasi menunjukan bahwasalinitas air tawar diduga meningkat dari 1.92 ppt hingga 4.86 ppt. (4) dari model hubungan antara intrusi air laut dan lebar jalur hijau menunjukan koefisien korelasi sekitar 0.97 dengan persamaan pendugaan intrusi air laut adalah 2264.9 * exp (-0.009 * lebar jalur hijau mangrove (m)), (5) jenis-jenis *Avicennia marina*, *Avecinnia alba*, *Rhizophora styllosa*, *Sonneratia alba* dan *Sonneratia caseolaris* merupakan jenis mangrove yang memiliki kemampuan terbaik untuk mengurangi intrusi air laut.

Kata kunci: Intrusi air laut, mangrove, salinitas air, analisis sistem

GENETIC DIVERSITY OF SENGON (*Falcataria moluccana* (Miq.) Barneby & J.W.Grimes) REVEALED USING SINGLE NUCLEOTIDE POLYMORPHISM (SNP) MARKERS

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GENETIC DIVERSITY OF SENGON (*Falcataria moluccana* (Miq.) Barneby & J.W. Grimes) REVEALED USING SINGLE NUCLEOTIDE POLYMORPHISM (SNP) MARKERS. Knowledge on genetic diversity and relationship between population is important for genetic conservation and breeding program. This paper describes the use of Single Nucleotide Polymorphism (SNP) markers for genetic diversity and relationship of sengon (*Falcataria moluccana* (Miq.) Barneby & J.W. Grimes). Twelve single nucleotide polymorphism (SNP) markers which were analyzed from Candiroto Seed Orchard samples showed that the genetic diversity of the total population is relatively high (H_e=0.359±0.128). Sengon from Wamena in Papua achieved the highest level of genetic diversity, while sengon from Java region was the least genetic diversity. The genetic relationship analysis showed three main clusters i.e. the first cluster consisted of Wamena and East Java, each close to Biak, and the Makian Island; the second cluster consisted of Central Java and West Java which are close to Mindanao Island; the third cluster consisted of Halmahera only. These genetic relationship information can be used to support breeding program and population genetic of sengon. For example in the collection of seed for the development of the next sengon seed orchard, it is important to minimize collecting genetic material from Java Island because the populations have low genetic diversity and there was close genetic relationship with sengon from Papua and Mindanao Island. Meanwhile, collecting genetic material for sengon from Biak and Wamena in Papua and Halmahera in Maluku could be directly and separately collected because of its high genetic diversity and cluster differences.

Keywords: Sengon (*Falcataria moluccana*), genetic diversity, genetic relationship, SNP markers

KERAGAMAN GENETIK SENGON (<u>Falcataria</u> <u>moluccana</u>* (Miq.) Barneby & J.W.Grimes) MENGGUNAKAN PENANDA SINGLE NUCLEOTIDE POLYMORPHISM (SNP). Pengetahuan tentang keragaman genetik dan hubungan kekerabatan antara populasi merupakan hal penting bagi konservasi genetik dan program pemuliaan pohon.Tulisan ini mempelajari penggunaan penanda SNP untuk mengetahui keragaman genetik dan hubungan kekerabatan sengon. Analisa dua belas penanda Single Nucleotide Polymorphism (SNP) pada sengon di kebun benih Candiroto Jawa Tengah menunjukkan bahwa total populasi mempunyai keragaman genetik yang tinggi (H_e=0.359±0.128). Sengon dari Wamena mempunyai keragaman genetik tertinggi sementara sengon dari wilayah Jawa terkecil. Hasil analisa hubungan kekerabatan menunjukkan sengon terbagi dalam tiga cluster; yang pertama, sengon dari Jawa Timur dekat dengan Wamena, yang keduanya ter-cluster dengan Biak dan kemudian Pulau Makian; cluster kedua, Jawa Barat dan Jawa Tengah dengan Pulau Mindanao; dan terakhir Halmahera. Informasi hubungan kekerabatan ini dapat digunakan untuk mendukung program pemuliaan pohon dan populasi genetik sengon. Sebagai contoh untuk koleksi materi genetik sebagai bahan pembangunan kebun benih sengon selanjutnya perlu meminimalkan pengambilan materi genetik dari Jawa karena selain mempunyai keragaman genetik yang lebih rendah dari populasi lainnya, juga terindikasi mempunyai hubungan kekerabatan yang dekat dengan sengon dari Papua dan Mindanao. Sementara sengon dari Biak dan Wamena di Papua dan Halmahera di Maluku dapat secara langsung dikoleksi karena mempunyai keragaman geneitik yang tinggi dan cluster yang berbeda.*

Kata kunci: Sengon (<u>Falcataria</u> <u>moluccana</u>), keragaman genetik, hubungan kekerabatan, penanda SNP

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I. INTRODUCTION

Sengon (*Falcataria moluccana* (Miq.) Barneby & J.W. Grimes), synonym names *Albizia falcataria* (L) Fosberg and *Paraserianthes falcataria* (L) Nielsen (Argent et al., 1996), is one of the valuable economic species in Indonesia. It has natural distribution in the Moluccas, New Guinea, the Bismarck Archipelago and the Solomon Islands (Soerianegara & Lemmens, 1994; Argent et al., 1996). It grows in primary and secondary rainforest, often on river flood terraces; on sandy soils up to 1600 m altitude (Argent et al., 1996) or up to 2300 m altitude (Soerianegara & Lemmens, 1994). It is a fast growing species often used for reforestation and afforestation or fire wood production (Soerianegara & Lemmens, 1994). The timber is used for light construction, house building and as furniture, sometimes to substitute pine wood; it is also planted as an ornamental and shade tree (Argent et al., 1996).

Knowing the genetic diversity and genetic relationship between populations is important for the genetic conservation and breeding program of sengon. Molecular genetic study using DNA markers provide an accurate method to examine genetic diversity. In Indonesia, several studies have been conducted to examine genetic diversity of sengon in natural population and plantation. Initial isoenzyme technique using one natural population in Papua and three plantations in Java (Bogor, Purworejo and Kediri) showed that the natural population of sengon in Papua has higher level of genetic diversity (0.163) than Java plantations (0.077-0.118) (Seido, Widyatmoko, & Nursinggih, 1993). Seido and Widyatmoko, 1994) also found (0.146-196) in four natural populations in Wamena, Papua. Meanwhile, a high level of genetic diversity (H_e=0.281) was found in a study using RAPD marker in progeny testing of sengon from Solomon in Cirangsad Experimental Forest in Jasinga Bogor (Dwiyanti, 2009).

Single nucleotide polymorphisms (SNPs) have been proposed as the new frontier for population studies (Morin, Martien, & Taylor, 2009). SNP is a variation of a single nucleotide between individuals and these polymorphisms can therefore be used to discern small differences both within population and among different populations (Norrgard & Schultz, 2008). SNPs offer significant advantages relative to microsatellites such as lower error rates, the ability to combine and add to data overtime and space, a simple mutation model with low homoplasy and many technologies for high genotyping efficiency (Gupta, Roy, & Prasad, 2001; Vignal, Milan, SanCristobal, & Eggen, 2002; Batley, Mogg, Edwards, O'Sullivan, & Edwards, 2003; Morin et al., 2009). SNPs have been used as markers for genetic diversity studies, genetic mapping or population structure in plants (Deulvot et al., 2010; Foster et al., 2010; Inghelandt, Melchinger, Lebreton, & Stich, 2010).

The ability of SNPs to discriminate between populations differs from that of microsatellite markers as their power comes not from the number of alleles but the large number of loci that can be assessed (Foster et al., 2010). Thus SNP markers have discriminatory power even in a low diversity species, once the rare SNPs are discovered (Foster et al., 2010). Osman et al. (2003) has also indicated that SNP markers provide more sensitive assays of genetic diversity than isozyme markers. The purpose of this paper was to examine the genetic diversity and genetic relationship of sengon population in Candiroto seed orchard, Central Java.

II. MATERIAL AND METHOD

A. Sample Collections

The Candiroto Seed Orchard in Central Java, Indonesia was established in 1994 (Susanto & Hashimoto, 1996). It consists of sengon trees collected from four regions in Indonesia: Biak and Wamena, Papua; Halmahera and Makian Island, Maluku; and West, East and Central Java, in Java; and a fourth region, Mindanao Island, Philippines (Figure 1). A total of 76 individual trees (Table 1) which are representing

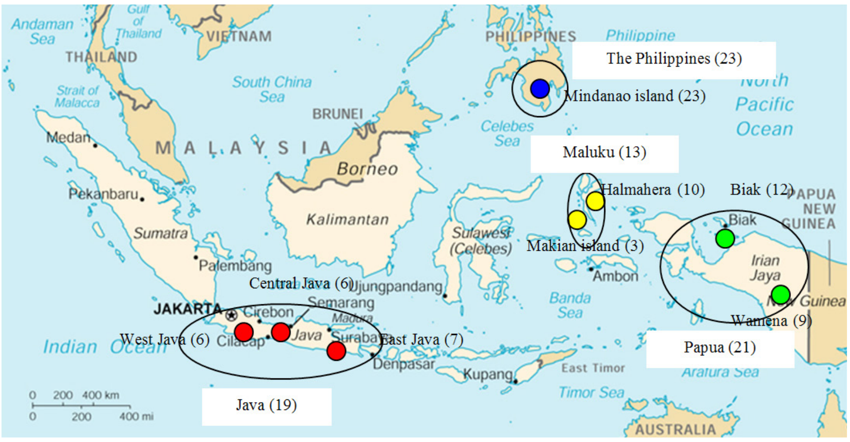

Figure 1. Sources of material of sengon (*F. moluccana*) from several regions in Indonesia and the Philippines, collected in Candiroto Seed Orchard.

Remarks : Numbers in parentheses are number of trees from each region used in this study. Big open circles define populations in Java (red), Papua (green), Maluku (yellow) and the Philippines (blue).

Tabel 1. Number of samples used for genetic diversity study in sengon

Region	**Area**	**Number of samples**
Papua	Biak	12
	Wamena	9
Maluku	Halmahera	10
	Makian Island	3
Java	Central Java	6
	East Java	7
	West Java	6
The Philippines	Mindanao Island	23
	Total	76

all populations in the orchard was randomly selected and used as material in this study. The number of samples for each region and population varied from 13-23 samples and 3-23 samples, respectively (Figure 1 and Table 1).

B. DNA Analysis

Twelve SNP markers were multiplexed into three sets for Single Nucleotide Primer Extension (SNuPE) analyses (Yuskianti & Shiraishi, 2010a) and were used in the study. The three sets of SNuPE analyses used in this study were obtained from an extensive search for polymorphism in 288 RAPD primers (Yuskianti, 2011). The DNA analysis was performed following the procedure by Yuskianti and Shiraishi (2010a). The genomic DNA was isolated using the modified CTAB method (Shirasihi & Watanabe, 1995) and purified using MagneSil (Promega) following the procedure described by the supplier. The DNA was analyzed using two-step amplification procedure (Yuskianti & Shiraishi, 2010a). The first amplification used balanced multiplex SCAR primers in the SCAR reaction, and the second balanced SNP extension primers. Those procedures stand into three sets of multiplex single nucleotide primer extension (SNuPE) analyses. Both PCR products were purified using Alkaline Phospatase and Exonuclease I. The fluorescently labelled product was then diluted with Hi-Di Formamide and LIZ-120 internal sizing standard. DNA fragment separations were determined using a 3130 Genetic Analyzer with POP7 (Applied Biosystems) and data analysis was performed using GeneMapper v3.7 (Applied Biosystems).

C. Data Analysis

Data were scored as presence and absence of major and minor alleles (homozygous) or presence of both alleles (heterozygous) for each sample. The genetic diversity parameters were mean number of observed alleles (N_a), mean effective number of alleles (N_e), the percentage of polymorphic loci (P), observed (H_o) and expected (H_e) heterozygosity based on Nei (1973), and F-statistics were calculated using POPGENE v1.31 (Yeh, Yang, & Boyle, 1999). Gene flow (N_m) was estimated using the formula N_m=0.25 (1-F_{ST})/F_{ST}, where F_{ST}=the degree of gene differentiation among populations. The genetic distance and genetic relationship between populations were shown using an unweighted pair-group method with arithmetic means (UPGMA) dendogram generated using the Tree program from MEGA v.5 Software (Tamura et al., 2011).

III. RESULT AND DISCUSSION

A high percentage of polymorphic loci (P) was generally obtained (≥ 75%). The mean observed number of alleles (N_a) ranged from 1.833 ± 0.389 to 2.000 ± 0.000 whereas the mean effective number of alleles (Ne) ranged from 1.374 ±0.265 to 1.622 ±0.296 (Table 2). In all populations, the mean observed heterozygosity (H_o) was higher than its expected heterozygosity (H_e) which measures the level of genetic diversity. At the population level, H_e varied from 0.247 ± 0.147 to 0.363 ± 0.125. The highest level of genetic diversity was Wamena, Papua (H_e=0.363 ± 0.125), followed by Biak, Papua (H_e=0.338±0.127) and Makian Island, Maluku (H_e=0.333±0.142). The level of genetic diversity (H_e) in the total population was 0.359±0.128 (Table 2). The higher level of observed heterozygosity (H_o) than H_e has indicated anisolate-breaking effect (the mixing of two previously isolated populations) (McDonald, 2008) as showed in Java populations. It is also showed that the population has a system of mating in which inbreeding is avoided (Gliddon & Goudet, 1994).

The level of genetic diversity obtained by SNP markers are generally lower than SSR markers. A population structure and genetic diversity based on 1,537 elite maize inbred lines using 359 SSR and 8,8244 SNP markers found the total gene diversity was 0.69 for the SSRs and half as much (0.32) for the SNPs (Inghelandt et al., 2010). A similar result was found in 2273 accessions of domesticated grapevine analyzed using 22 common SSR and 384 SNP markers, the average genetic diversity was higher for SSR loci (0.81) than for SNPs (0.34) (Emanuelli et al., 2013).

Sengon in the total population of the Candiroto Seed Orchard was considered to have a high level of genetic diversity (He=0.359). This level is comparable with other study using 372 SNPs in 300 representative rice inbred lines from 22 rice growing countries worlwide; the average level of genetic diversity was 0.358 (Chen et al., 2011). Several specific markers such as SCAR markers (Yuskianti & Shiraishi, 2010b), SNP markers (Yuskianti & Shiraishi, 2010a) and eight microsatelllite markers (Saito, Lian, Ishio, & Ide, 2014) have been developed, however, only isoenzym and RAPD markers are the most commonly used markers for sengon studies (e.g. Suharyanto, Rimbawanto, & Isoda, 2002; Dwiyanti, 2009). The result from SNP markers that rely only on one base differences in DNA sequences provided high discrimination power; almost 100% (1.000 of Discrimination Power/DP) (Yuskianti & Shiraishi, 2010a). The low number of samples from Makian Island has limited its application for the area, however other information is important to support breeding program and population genetic studies in sengon.

The level of genetic diversity of sengon in this study was high (H_e = 0.359) (Table 2), higher than previous sengon studies. Previous studies

Table 2. Summary of genetic diversity in sengon (*Falcataria moluccana*) populations#

Region	Population	N_a	N_e	P	H_o	H_e
Papua	Biak	2.000 (0.000)	1.563 (0.304)	100	0.724 (0.104)	0.338 (0.127)
	Wamena	2.000 (0.000)	1.622 (0.296)	100	0.719 (0.166)	0.363 (0.125)
Maluku	Halmahera	1.917 (0.289)	1.523 (0.320)	91.67	0.783 (0.189)	0.314 (0.156)
	Makian Island	1.917 (0.289)	1.559 (0.310)	91.67	0.722 (0.193)	0.333 (0.142)
Java	Central Java	1.833 (0.389)	1.374 (0.265)	83.33	0.681 (0.219)	0.247 (0.147)
	East Java	1.917 (0.289)	1.525 (0.379)	91.67	0.762 (0.141)	0.306 (0.169)
	West Java	1.750 (0.452)	1.529 (0.395)	75	0.736 (0.241)	0.299 (0.199)
Mindanao Island	Mindanao Island	2.000 (0.000)	1.561 (0.347)	100	0.670 (0.153)	0.329 (0.152)
Total		**2.000 (0.000)**	**1.619 (0.321)**	**100**	**0.715 (0.109)**	**0.359 (0.128)**

Remarks: #N_a=Mean observed number of alleles, N_e=Mean effective number of alleles, P=The percentage of polymorphic loci, H_o=Mean observed heteroygosity, H_e=Mean expected heterozygosity. Values in parentheses are standard de viations.

using isoenzym showed that H_e of five natural stands in Papua varied between 0.146 and 0.196 (Seido et al., 1993; Seido & Widyatmoko, 1994), and 0.077-0.118 for three plantations of sengon in Java (Seido et al., 1993). Furthermore, RAPD marker studies obtained H_e=0.226 for an introduced population at Kediri, East Java (Siregar, Basyuni, Sudarmonowati, & Iriantono, 1998), 0.2183 for progeny trial of sengon from Solomon in Cirangsad trial, West Java (Dwiyanti, 2009) and 0.2349 from community forest in Java (Siregar & Olivia, 2013).

Though the varying genetic diversities obtained may be caused by differences of DNA markers used, number of samples and also origin of collected materials; however, this study support previous genetic studies in sengon. Sengon in the SSO collected from Wamena, Papua had the highest level of genetic diversity (H_e=0.363) has corroborated the finding that the Wamena population is the highest levels of genetic diversity (Seido et al., 1993). While the level of genetic diversity of sengon from Java in this study (H_e=0.247 to 0.306) (Table 2) was comparable with previous RAPD studies (Dwiyanti, 2009; Siregar et al., 1998; Siregar & Olivia, 2013).

The genetic relationship among all population shows in genetic distance data (Tabel 3) and UPGMA dendogram (Figure 2). The genetic distance analysis indicated a close genetic relationship among population of sengon in Java region and between Java and Papua. East Java and Wamena has the lowest genetic distance (0.017), followed by 0.028 for West Java and Central Java, 0.038 for East Java and Central Java, and Central Java and Wamena (Table 3). Sengon from Maluku especially Halmahera consistently showed its distinctive genetic composition with other populations (Table 3).

The genetic distance data is also supported

Table 3. Genetic distance of eight populations of sengon (*F. moluccana*)

Pop ID	Biak	Wamena	Halmahera	Makian Island	Central Java	East Java	West Java	Mindanao Island
Biak	0							
Wamena	0.018	0						
Halmahera	0.056	0.088	0					
Makian Island	0.054	0.051	0.109	0				
Central Java	0.068	0.038	0.229	0.082	0			
East Java	0,033	0.017	0.131	0.085	0.038	0		
West Java	0.086	0.047	0.204	0.093	0.028	0.057	0	
Mindanao Island	0.055	0.036	0.171	0.059	0.028	0.042	0.032	0

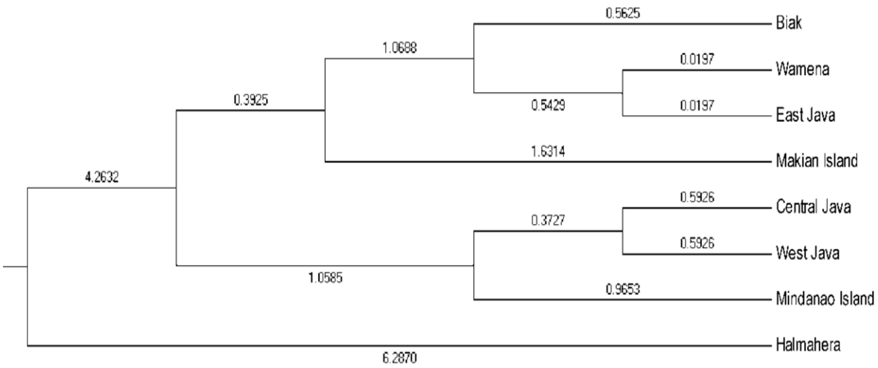

Figure 2. UPGMA dendrogram showing the genetic relationships among sengon populations

by the UPGMA dendogram that showed different clusters between Maluku and other areas. The UPGMA showed three main clusters. The first cluster consisted of Wamena and East Java, each close to Biak, then Makian Island; the second cluster consisted of Central Java and West Java which were close to Mindanao Island; and the third cluster consisted of Halmahera only (Figure 2).

The result obtained from this study supports the previous study using isoenzyme (Seido et al., 1993). The low genetic diversity (Table 2) and low genetic distance between population in Java (Table 3) indicated the similarity of genetic composition of sengon from East, West and Central Java population. Seido et al. (1993) also found that genetic composition of Java population (Bogor, Purworejo and Kediri) were closely related to each other and genetically very similar to one another. Both studies have clarified that sengon in Java is the result of man-made forests (plantation or community forest) and it is not part of a natural distribution of sengon in Indonesia. Sengon was firstly introduced from an area i.e. Banda Island to Bogor Botanical Garden in 1871 and spread to other parts of Java Island (Heyne, 1987).

This study also confirmed the previous study using RAPD markers that sengon in Java was closely related to the sengon from Biak and Wamena, Papua (Suharyanto et al., 2002). Our study indicates that only sengon from East Java has close genetic relationship with sengon from Wamena and Biak (Figure 2) while others have different relationships. The indication of close relationship between sengon from West

Table 4. Summary of F-statistics and Gene flow (N_m) for 12 SNP loci

Locus	Sample size	F_{IS}	F_{IT}	F_{ST}	N_m
A1	152	0.158	0.331	0.205	0.967
A2	152	-0.197	-0.095	0.085	2.692
A3	150	0.242	0.317	0.099	2.279
A4	152	-0.172	-0.120	0.044	5.481
B1	142	0.513	0.543	0.062	3.780
B2	150	-0.009	0.118	0.127	1.722
B3	150	0.205	0.367	0.204	0.975
B4	152	0.577	0.663	0.203	0.983
C1	150	-0.057	0.011	0.064	3.679
C2	152	0.181	0.226	0.055	4.3077
C3	152	0.044	0.115	0.074	3.135
C4	152	-0.160	-0.136	0.020	12.015
Mean	150	0.124	0.226	0.117	1.895

and Central Java with sengon from Mindanao, Phillipines, as this is the first time to observe, it is important to further examine. The number of samples from Java and Mindanao is limited in this study, so more studies using more number of samples to clarify this relationship is needed.

Population genetic studies provide insights into evolutionary processes, and F_{ST}, which plays a central role in ecological and evolutionary genetic studies (Willing, Dreyer, & van Oosterhout, 2012), is among the most widely used measure of genetic differentiation. Our study revealed genetic differentiation among the eight sengon population examined was moderate (F_{ST}=0.117) with a moderate level of gene flow for all population (N_m=1.895) (Table 4).

Estimation of F_{ST} and N_m can be biased if limited by the loci used. SNPs are biallelic markers (Vignal et al., 2002), so the number and type required for the greatest statistical power has been vigorously debated; ~30 SNPs is suggested to be sufficient to detect moderate (F_{ST}=0.01) levels of differentiation (Morin et al., 2009). Inghelandt et al. (2010) proposed the use of 7 and 11 times more SNPs than SSRs for respectively analyzing population structure and genetic diversity. However population sample size (*n*) can be significantly reduced (*n*=4 to 6) when using an appropriate estimator and a large number (>1,000) of bi-allelic genetic markers (Willing et al., 2012). Analysis of genetic diversity of sengon in this study is estimated to be sufficient to obtain reliable data because it is used 12 SNP markers that are proven to have almost a 100% discrimination power (Yuskianti & Shiraishi, 2010a).

This high genetic diversity of sengon in Candiroto Seed Orchard showed the succesful genetic material collection in the orchard. The orchard, however could not be further utilized because of illegal logging and pest and disease attack that limit the number of existing trees in the orchard. Though the seed orchard could not be further utilized as the information of the genetic relationship is still possible to be used in supporting tree improvement of sengon in the future. The study shows that sengon from Mindanao and Central and West Java are in one cluster, Wamena, East Java and Biak then Makian Island in different cluster while Halmahera stands alone in a separate cluster (Figure 2), brings an impact for management of seed orchards. For example in sample collection, sengon from Halmahera (this study has strengthened the distinctive genetic relationship of sengon from Halmahera as found in RAPD study (Suharyanto et al., 2002)) and sengon from Papua (Wamena and Biak) can be separately collected. Careful collection is needed when doing collection from Java Island because sengon from different areas in Java indicated close relationship with sengon from Mindanao and Papua (Figure 2). This caution need to be considered to avoid inbreeding depression.

Other results could also be used to support population genetic studies of sengon. This study indicates that Papua and Maluku might be the center of gene (gene pool) of sengon in Indonesia. This allegation is based on the genetic diversity (Table 2) and genetic relationship (Table 3 and Figure 2). This indication is possible because the natural distribution of sengon is in the Moluccas, New Guinea, the Bismarck Archipelago and the Solomon Islands (Soerianegara & Lemmens, 1994; Argent et al., 1996).

Furthermore, there is also an indication of the presence of effective border for sengon deployment in Eastern of Indonesia. Papua and Maluku though located in close area, however both areas are surrounded by sea and rich with small islands. The presence of sea is effective to avoid spreading of sengon to other areas. This condition found in our SNP study (Figure 2) and RAPD study (Suharyanto et al., 2002) where sengon from Halmahera in Maluku has different cluster than other areas in Indonesia. The remoteness and difficulty to access the island has caused limited deployment of sengon from Halmahera to other areas. This is different with sengon from Papua that has large sample size as it is located on a big island (Figure 1) and relatively easy to access. This accessable location has caused sengon from Papua to easily spread to other areas such as to Java. Human activities seems to bring significant impact to seed transfer from Papua to other areas in Indonesia. More studies using more samples from many natural distributions therefore are needed to understand gene flow, seed transfer and evolution of sengon in Indonesia.

IV. CONCLUSION

A high genetic diversity was found from the total population of sengon in Candiroto Seed Orchard indicating a succesful collection of genetic material for seed orchard. The seed orchard could not be further utilized because of limited number of existing trees, however the genetic relationship information can be used to support tree improvement and population genetics of sengon. The genetic relationship between sengon from several areas bring an impact on, for example in sample collection. Sengon from Halmahera, Maluku, and Wamena and Biak in Papua could be separately collected while genetic material collected from Java needs a caution because of its low genetic diversity and close relationship with sengon from Papua and Mindanao. The indication of a possible gene pool and the presence of effective border for sengon deployment in eastern Indonesia was also discovered in this study. More studies using more number of samples are required to understand the evolution of sengon in Indonesia.

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REFERENCES

Argent, G., Saridan, A., Campbell, E. J. F., Wilkie, P., Fairweather, G., Hadiah, J. T., … Yulita, K. S. (1996). *Manual of the larger and more important non dipterocarp trees of central Kalimantan Indonesia.*

(Vol 2). Samarinda: Forest Research Institute.

Batley, J., Mogg, R., Edwards, D., O'Sullivan, H., & Edwards, K. (2003). A high-throughput SNuPE assay for genotyping SNPs in the flanking regions of Zea mays sequence tagged simple sequence repeats. *Molecular Breeding*, *11*(2), 111–120. doi:10.1023/A:1022446021230.

Chen, H., He, H., Zou, Y., Chen, W., Yu, R., Liu, X., … Deng, X. (2011). Development and application of a set of breeder-friendly SNP markers for genetic analyses and molecular breeding of rice (*Oryza sativa* L.). *Theoretical Applied Genetics*, *123*(6), 869–79. doi:10.1007/s00122-011-1633-5.

Deulvot, C., Charrel, H., Marty, A., Jacquin, F., Donnadieu, C., Lejeune-Hénaut, I., … Aubert, G. (2010). Highly-multiplexed SNP genotyping for genetic mapping and germplasm diversity studies in pea. *BMC Genomics*, *11*, 468. doi:10.1186/1471-2164-11-468

Dwiyanti, F. G. (2009). *Keragaman sengon solomon* (*Paraserianthes falcataria* (L) Nielsen) *pada uji keturunan di hutan percobaan cirangsad*. (Skripsi). Institut Pertanian Bogor, Bogor.

Emanuelli, F., Lorenzi, S., Grzeskowiak, L., Catalano, V., Stefanini, M., Troggio, M., … Grando, M. S. (2013). Genetic diversity and population structure assessed by SSR and SNP markers in a large germplasm collection of grape. *BMC Plant Biology, 13*, 39. doi:10.1186/1471-2229-13-39

Foster, J., Allan, G., Chan, A., Rabinowicz, P., Ravel, J., Jackson, P., & Keim, P. (2010). Single nucleotide polymorphisms for assessing genetic diversity in castor bean (*Ricinus communis*). *BMC Plant Biology*, *10*, 13. doi:10.1186/1471-2229-10-13.

Gliddon, C., & Goudet, J. (1994). The genetic structure of metapopulations ad conservation biology. In Loeschke, J. Tomiuk, & S.K. Jain (Eds). *Conservation genetic*. Basel-Boston-Berlin, Germany: Birkhauser Verlag.

Gupta, P. K., Roy, J. K., & Prasad, M. (2001). Single nucleotide polymorphisms (SNPs): A new paradigm in molecular marker technology and DNA polymorphism detection with emphasis on their use in plants. *Current Science*, *80*(4), 524–535.

Heyne, K. (1987). *Tumbuhan berguna Indonesia*. Jakarta. Badan Litbang Kehutanan, Departemen Kehutanan.

Inghelandt, D. V., Melchinger, A. E., Lebreton, C., & Stich, B. (2010). Population structure and genetic diversity in a commercial maize breeding program assessed with SSR and SNP markers. *Theoretical Appllied Genetics*, *120*(7), 1289–1299.doi:10.1007/s00122-009-1256-2.

McDonald, D. B. (2008). Heterozygosity, HExp (or gene diversity, D). *Lecture 4. Population Genetics II*. Retrieved from http://www.uwyo.edu/dbmcd/molmark/lect04/lect4.html on September 20, 2017.

Morin, P., Martien, K., & Taylor, B. (2009). Assessing statistical power of SNPs for population structure and conservation studies. *Molecular Ecology Resources*, *9*(1), 66–73. doi:10.1111/j.1755-0998.2008.02392.x.

Nei, M. (1973). Analysis of gene diversity in subdivided populations. *Proceedings of the Natural Academy of Sciences of the United States of America* (Vol. 70, pp. 3321–3323).

Norrgard, K., & Schultz, J. (2008). Using SNP data to examine human phenotypic differences. *Nature Education*, *1*(1), 85.

Osman, A., Jordan, B., Lessard, P., Muhammad, N., Haron, M., Riffin, N., … Housman, D. (2003). Genetic diversity of *Eurycoma longifolia* inferred from single nucleotide polymorphisms. *Plant Physiology*, *131*(3), 1294–1301.

Saito, Y., Lian, C., Ishio, S., & Ide, Y. (2014). Isolation and characterisation of eight microsatellite markers in *Paraserianthes falcataria*, a fast growing tropical leguminous tree species. *Journal of Tropical Forest Science*, *26*(2), 295–297.

Seido, K., & Widyatmoko, A. Y. P. B. C. (1994). *Genetic variation of natural stands of Paraserianthes falcataria at Wamena in Irian Jaya, FTIP-No.16*. Yogyakarta: Japan International Cooperation Agency (JICA) and Directorate General of Reforestation and Land Rehabilitation Ministry of Forestry Indonesia.

Seido, K., Widyatmoko, A. Y. P. B. C., & Nursinggih, H. (1993). *Genetic variation at four allozyme loci in Paraserianthes falcataria, FTIP-No.12*. Yogyakarta: Japan International Cooperation Agency (JICA) and Directorate General of Reforestation and Land Rehabilitation Ministry of Forestry Indonesia.

Shirasihi, S., & Watanabe, A. (1995). Identification of chloroplast genome between *Pinus densiflora* SIEB. et ZUCC. and *P. thunbergii* PARL. based on the polymorphism in rbcL gene. *Journal of The Japanese Forestry Society*, *77*(5), 429–436.

Siregar, U. J., Basyuni, M., Sudarmonowati, E., & Iriantono, D. (1998). Genetic diversity in a *Paraserianthes falcataria* provenance trial in Parung Panjang, Bogor Indonesia. In O. Mohamad, M. Z. Mohd. Khalid, Z. Zulkeflie, M. Y. Mohd. Khusary, S. L. Lee, … R. Rozita (Eds.), *Proceedings in the Third National Congress on Genetics* (pp. 114–117). Malaysia: Persatuan Genetik Malaysia, University Kebangsaan Malaysia.

Siregar, U. J., & Olivia, R. D. (2013). Keragaman genetik populasi sengon (*Paraserianthes falcataria* (L) Nielsen) pada hutan rakyat di jawa berdasarkan penanda RAPD. *Jurnal Silvikultur Tropika*, *3*(2), 130–136.

Soerianegara, I., & Lemmens, R. H. M. J. (1994). *PROSEA, Plant Resources of South-East Asia 5: (1) Timber trees: Major commercial timbers*. Bogor: Prosea Foundation, Bogor Indonesia and Pudoc-DLO, Wageningen, Netherlands.

Suharyanto, Rimbawanto, A., & Isoda, K. (2002). Genetic diversity and relationship analysis of *Paraserianthes falcataria* revealed by RAPD marker. In A. Rimbawanto & M. Susanto (Eds.), *Advances in Genetic Improvement of Tropical Tree Species* (pp. 81–88). Yogyakarta: Centre for Forest Biotechnology and Tree Improvement.

Susanto, M., & Hashimoto, K. (1996). *General information of seed source establishment of Paraserianthes falcataria in Candiroto, Central Java Fiscal year 1995/1996, FTIP No.43*. Yogyakarta: Japan International Cooperation Agency (JICA) and Directorate General of Reforestation and Land Rehabilitation Ministry of Forestry Indonesia.

Tamura, K., Peterson, D., Peterson, N., Stecher, G., Nei, M., & Kumar, S. (2011). MEGA 5: Molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and maximum parsimony methods. *Molecular Biology and Evolution*, *28*(10), 2731–2739. doi:10.1093/molbev/msr121.

Vignal, A., Milan, D., SanCristobal, M., & Eggen, A. (2002). A review on SNP and other types of molecular markers and their use in animal genetics. *Genetics Selection Evolution*, *34*(3), 275–305. doi:10.1051/gse:2002009.

Willing, E. M., Dreyer, C., & van Oosterhout, C. (2012). Estimates of genetic differentiation measured by fst do not necessarily require large sample sizes when using many snp markers. *PLoS ONE*, *7*(8), e42649. doi:10.1371/journal.pone.0042649.

Yeh, F. C., Yang, R., & Boyle, T. (1999). Popgene version 1.31. Microsoft Window-based freeware for population genetic analysis. *Quick user guide*. Edmonton, Canada: University of Alberta and Centre for International Forestry Research. Retrieved from http://www.ualberta.ca/~fyeh/popgene.pdf.

Yuskianti, V. (2011). Fragmen polimorfik penanda RAPD untuk analisis genetik sengon (Falcataria moluccana). *Jurnal Pemuliaan Tanaman Hutan*, *5*(1), 55–61.

Yuskianti, V., & Shiraishi, S. (2010a). Developing SNP markers and DNA typing using multiplexed single nucleotide primer extension (SNuPE) in *Paraserianthes falcataria*. *Breeding Science*, *60*(1), 87–92. doi:10.1270/jsbbs.60.87.

Yuskianti, V., & Shiraishi, S. (2010b). Sequence characterized amplified region (SCAR) markers in sengon (*Paraseriathes falcataria* (L.) Nielsen. *HAYATI Journal of Biosciences*, *17*(4), 167–172. doi:10.4308/hjb.17.4.167.

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TREE SPECIES COMPOSITION OF 1.8 HA PLOT SAMBOJA RESEARCH FOREST: 28 YEARS AFTER INITIAL FIRE

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TREE SPECIES COMPOSITION OF 1.8 HA PLOT SAMBOJA RESEARCH: 28 YEARS AFTER INITIAL FIRE. Repeated forest fires highly impact on tree species composition. Forest planning requires information about the current condition of species composition. This paper investigates the current tree composition of natural regeneration after repeated forest fires, regeneration process after repeated fires, and strategy of secondary growth related to ecological restoration issues. Re-observation of the 1.8 hectares permanent plot in Samboja Research Forest was conducted in 2011. All trees with diameters above 10 cm at breast height (DBH) were re-numbered and mapped. Herbarium specimen was collected for species identification. Number of taxon was determined, Important Value Index was calculated, species trait of light response was identified based on the references and dispersion index species was calculated. Results show after twenty eight years initial forest fire, 191 species naturally regenerated in the burnt area. *Macaranga gigantea*, a light demanding pioneer species of Euphorbiaceae was the most dominant species, followed by *Vernonia arborea* belonging to Asteraceae. Both, *M. gigantea* and *V. arborea* had clumped distribution. Eight species identified survived from repeated fires, are *Anthocephalus chinensis*, *Dipterocarpus cornutus*, *Diospyros borneensis*, *Eusideroxylon zwageri*, *Shorea ovalis*, *Syzygium borneensis*, *Pholidocarpus majadum* and *Vatica umbonata*. All surviving species was distributed uniformly in the plot. Dominant pioneer species which has grown after repeated fires indicates that the current condition of burnt forest is in the early succession. Protecting forest, assisting natural regeneration and monitoring dominant species are suggested as activities for the ecological restoration.

Keywords: Ecological restoration, East Kalimantan, forest fire, species composition

KOMPOSISI JENIS POHON PADA PETAK SELUAS 1,8 HA DI HUTAN PENELITIAN SAMBOJA: 28 TAHUN SETELAH KEBAKARAN PERTAMA. Kebakaran hutan berulang berdampak besar terhadap komposisi jenis pohon. Perencanaan restorasi hutan memerlukan informasi mengenai komposisi jenis yang beregenerasi secara alami pada hutan bekas terbakar. Tulisan ini mempelajari jenis yang beregenerasi secara alami, proses regenerasi yang terjadi setelah kebakaran berulang, dan rekomendasi untuk implementasi restorasi pada hutan yang sedang beregenerasi. Pengamatan ulang terhadap petak permanen di KHDTK Samboja, Kalimantan Timur dilakukan tahun 2011. Semua pohon berdiameter di atas 10 cm pada sub-petak 10 m x 10 m dicatat, diukur DBH, dipetakan posisi koordinatnya dan diambil contoh daun untuk identifikasi tingkat jenis. Komposisi taksa, Indeks Nilai Penting dan indeks persebaran jenis dihitung. Karakter jenis berdasarkan responnya terhadap cahaya diidentifikasi. Dua puluh delapan tahun setelah kebakaran pertama, 191 jenis beregenerasi pada hutan bekas terbakar. Macaranga gigantea, *jenis pionir tergantung pada cahaya, famili Euphorbiaceae merupakan jenis paling dominan diikuti* Vernonia arborea *dari Asteraceae. Kedua jenis tersebut memiliki pola sebaran mengelompok. Delapan jenis diidentifikasi mampu bertahan dari kebakaran yaitu:* Anthocephalus chinensis, Dipterocarpus cornutus, Diospyros borneensis, Eusideroxylon zwageri, Shorea ovalis, Syzygium borneensis, Pholidocarpus majadum *dan* Vatica umbonata *yang semuanya menyebar secara seragam. Dominasi jenis pionir yang beregenerasi setelah kebakaran dan regenerasi spesies yang mampu bertahan dari kebakaran menunjukkan bahwa*

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kondisi hutan berada pada tahap awal suksesi. Perlindungan hutan, pemeliharaan permudaan alami, dan pemantauan spesies dominan merupakan kegiatan yang dianjurkan dalam restorasi ekologi.

Kata kunci: Kalimantan Timur, kebakaran hutan, komposisi spesies, restorasi ekologi

I. INTRODUCTION

Samboja Research Forest in East Kalimantan was suffered by major fires twice in 1982/1983 and 1997/1998. Fire is an important natural force which influences plant communities and affects the health of certain ecosystems (Nasi, Dennis, Meijaard, Applegate, & Moore, 2001). However, wildfires change plant communities by reducing some species dominance, while enhancing the abundance of others and creating vegetation patches in different successional states (Baeza, Valdecantos, Alloza, & Vallejo, 2007; Pyke, Brooks, & D'Antonio, 2010). Moreover, repeated fires cause tree species losses (Kim & Arthur, 2014; Peterson & Reich, 2008), because of the direct damage by fire, as well as its indirect impact due to ecological consequences after fire event that result in regeneration failure (Van Nieuwstadt & Sheil, 2005; Slik et al., 2010). For instance, in 2003 observations (twenty years after initial forest fire) on the permanent plot of Samboja Research Forest, only 60% of the species had recovered (Simbolon, 2005).

Macaranga gigantea was a minor species before fire developed vastly and was categorized as one of the three most dominant species in terms of population (Simbolon, 2005; Kartawinata et al., 2008). As a research forest, Samboja Research Forest, East Kalimantan, is an important site to study forest regeneration process after repeated fires. Furthermore, this basic data of the regeneration process providing an important information to set up ecological restoration program in disturbed forest of Samboja Research Forest, even as a model to develop similar activities for similar ecosystem condition.

Based on the succession theory of Clement (1916), initial growth of vegetation establishment and competition which are the early succession phases are dominated by light demanding pioneer species that can reach up to 35 years (Riswan, Kenworthy, & Kartawinata, 1985). Re-observing the permanent plot after 28 years since the initial fire or thirteen years after the second fire is important to get serial data from previous observations in 1981 and 2003 to understand the current condition, and the dynamic of species after affected by repeated fires. This paper investigates the current tree composition after repeated forest fires, the succession process after thirteen years repeated fires, and provides recommendation in the secondary growth related to ecological restoration issues.

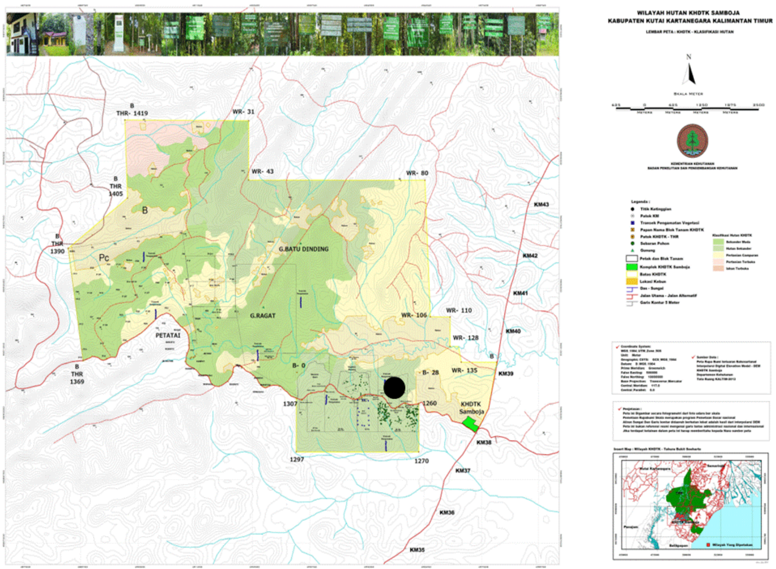
II. MATERIAL AND METHOD

A. Study Site

Tree species inventory was conducted in 2011 for 1.8 ha of the 10.5 ha permanent plot established by Indonesian Institute of Sciences (LIPI) during 1979-1981 as published by Kartawinata et al. (2008). Administratively, Samboja Research Forest is located in Kutai Kertanegara and Penajam Paser Utara Districts, East Kalimantan and geographycally is situated at 0°59'23" – 0°59'27" S and 116°57'31" – 116°57'51" E (Figure 1). This area was affected by repeated major fires in 1982/1983 and 1997/1998 and currently it is in the recovery process.

B. Methods

Enumeration of all trees above 10 cm diameter at breast height (DBH) was done in 10.5 hectare area that was divided by 10 m x 10 m sub-plots during 1979 – 1981. Tree DBH were recorded, tree positions were mapped and tagged. Herbarium specimens were collected for species identification purpose, identification process was conducted in Herbarium



Remarks:• is sample plot location

Figure 1. Samboja Research Forest

Bogoriense, Bogor (Kartawinata et al., 2008). Re-enumeration of all trees above 5 cm DBH was done in 2003 after affected by major fires 1982/1983 and 1997/1998 in 1.65 hectare (110 m x 150 m). Tree DBH were recorded, but only trees above 10 cm DBH were tagged during this observation (Simbolon, 2005). Re-enumeration of trees above 10 cm DBH was done in 2011 in 1.8 hectare (120 m x 150 m). Tree DBH was recorded and tree position was mapped.

C. Analysis

Number of individuals, genera and species of each family were determined. Tree position and DBH were visualized in the bubble graph. Important Value Index (IVI) was calculated from Relative Dominance, Relative Density and Relative Frequency of each species (Curtis, 1959):

$$IVI = RD + RF + RCi \qquad \text{.............................(1)}$$

Where:
RD = relative density, *D* = density of species *i*, *RF* = relative frequency, F = frequency of species *i*, *RCi* = relative dominance, *C* = dominance species *i*, *IVI* = Important Value Index.

Dispersion Index to quantify spatial distribution of each species in the sampled plot (Ludwig & Reynolds, 1988) was calculated using formula:

$$I_D = \frac{S^2}{\bar{x}} \qquad \text{...(2)}$$

Where:
I_D = dispersion index; S^2 = variance; $\bar{x}$ = average. Species distribute random if $I_D = 1$, uniform if $I_D < 1$ and clumped if $I_D > 1$.

Comparison to pre-fire species survey in 1981 as done by Kartawinata et al. (2008) was performed to determine whether tree species survived after repeated fires or not.

Functional group of succession stage was determined based on light demanding and shade tolerant species based on literatures.

III. RESULT AND DISCUSSION

A. Taxonomic Composition

There were 1075 surviving trees (dbh>10 cm) belonging to 191 species, 101 genus and 41 families that were recorded in the 1.8 ha hectare of twice burnt forest (i.e 1982/1983 and 1997/1998). Euphorbiaceae, Asteraceae and Moraceae were the families with the highest number of trees in the sample plot (Figure 2), which is occupied by *Macaranga gigantea*, *Vernonia arborea* and *Artocarpus anisophyllus*.

Euphorbiaceae, Rubiaceae and Lauraceae have the highest *genus* member, more than 5; Euphorbiaceae, Myristicaceae, Myrtaceae have the highest *species* member, more than 15 (Figure 3). Eight species were recorded belonging to *Macaranga* and two species of *Mallotus* as members of Euphorbiaceae.

B. Tree Density Composition

Tree density distributed unevenness among families (Figure 4). Euphorbiaceae has the highest number of trees in the sample plot, in which 263 trees from 10 genus and 25 species that covered 25% of the total population; followed by Asteraceae with 133 trees (12% of total population) belonging to a single genus and species of *V. arborea*. Twenty one families have less than 10 trees in the sample plot, which included Thymelaceae, Lecythidaceae, Burseraceae, Dilleniaceae, Sapindaceae, Rosaceae, Monimiaceae, Flacourtiaceae, Elaeocarpaceae, Combretaceae, Alangiaceae, Hypericaceae, Olacaceae, Melastomataceae, Apocynaceae, Rhizophoraceae, Sterculiaceae, Fagaceae, Ulmaceae, Theaceae and Clusiaceae. Eighten families have 10 to 100 trees, i.e. Dipterocarpaceae, Lauraceae, Rubiaceae, Anacardiaceae, Bombacaceae, Meliaceae, Sapotaceae, Tiliaceae, Fabaceae, Magnoliaceae, Moraceae, Verbenaceae, Rutaceae,

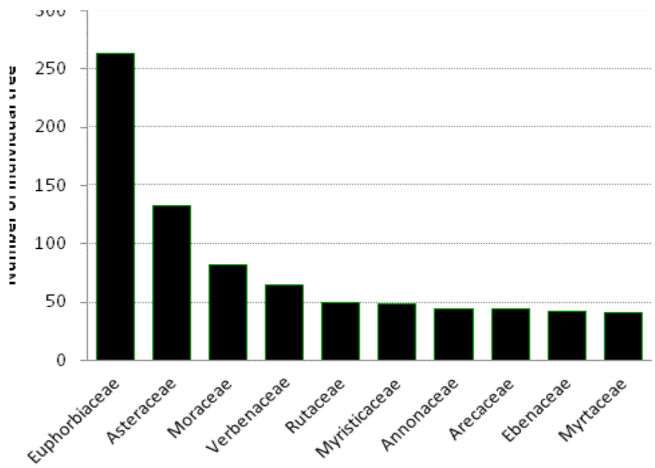


Figure 2. Families with highest number of trees

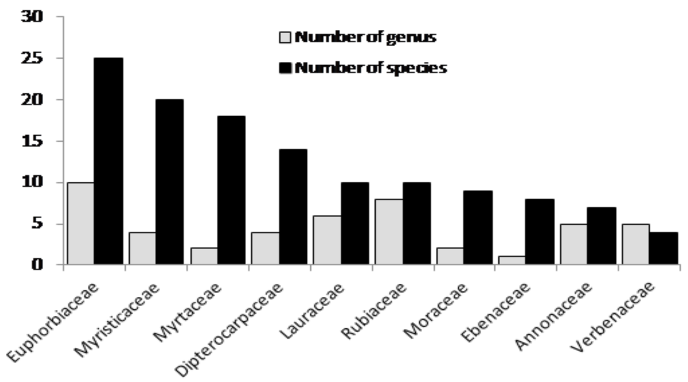


Figure 3. Ten families with highest number of genus and species

Myristicaceae, Annonaceae, Arecaceae, Ebenacea and Myrtaceae.

In the sample plot, the only a species of *Macaranga gigantea* (Euphorbiaceae) has more than 100 trees, nine species of *Vernonia arborea* (Asteraceae), *Artocarpus anisophyllus* (Moraceae), *Melicope glabra* (Rutaceae), *Pholidocarpus majadun* (Arecaceae), *Penorema canescens* (Verbenaceae), *Croton laeivifolius* (Euphorbiaceae), *Cananga odorata* (Meliaceae), *Macaranga hypoleuca* (Euphorbiaceae) and *Geunsia pentandra* (Verbenaceae) have 10 – 100 trees and another 80 species have 1 – 10 trees (Figure 5).

Diospyros borneensis, *Antho* , and *Cratoxylum racemosum* are surviving species with the highest tree density in the sample plot, mostly in the 10 – 20 cm DBH class.

C. Dominance Species

Important Value Index calculation in the sample plot found that 2 of 191 species has the highest IVI, i.e. *Macaranga gigantea* (35.3) and *Vernonia arborea* (30.5) that covered more than 20% of the total IVI. As well as, 3 of 191 species covered 30% of the total IVI, which included *Pholidocarpus majadun* (13.0), *Artocarpus anisophyllus* (12.3) and *Melicope glabra* (12.2).

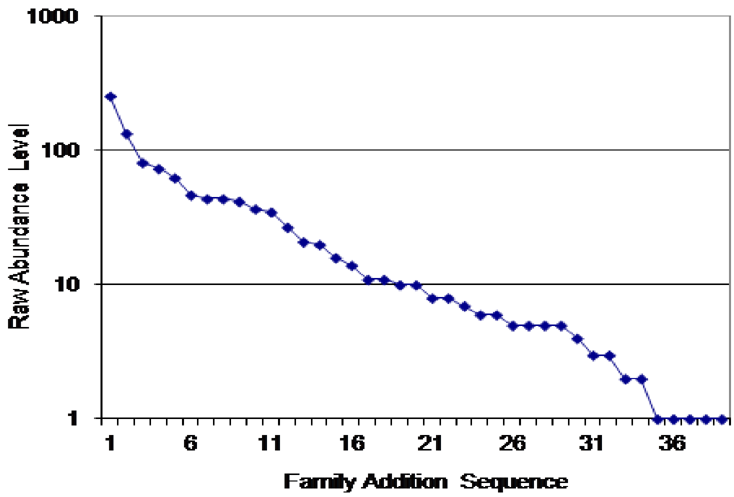


Figure 4. Family rank abundance curve

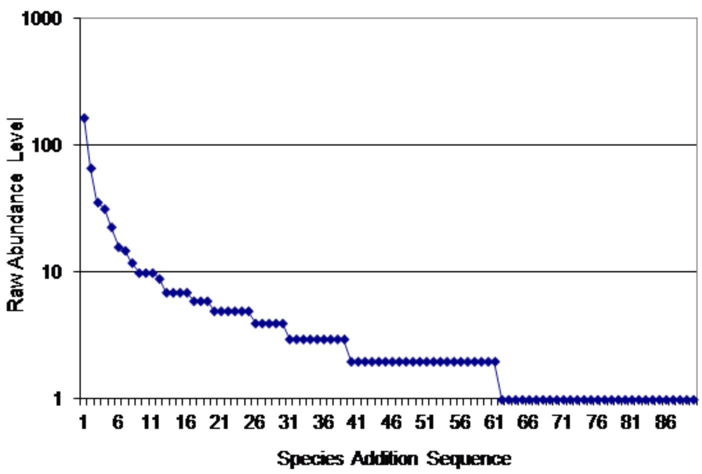


Figure 5. Species rank abundance curve

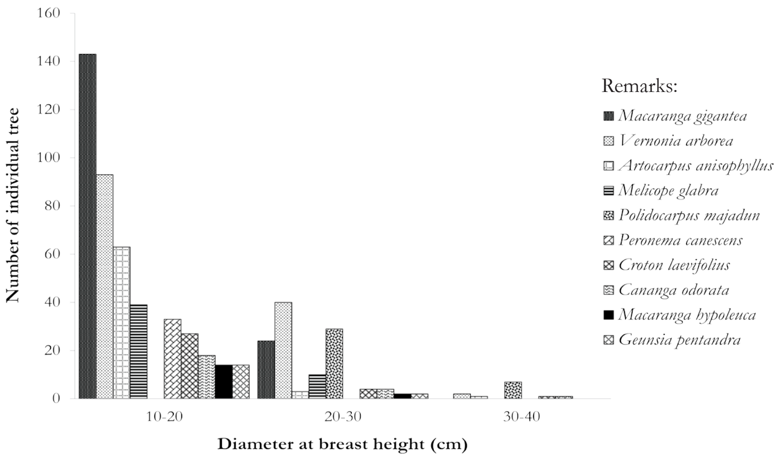


Figure 6. Ten species with the highest number of trees and the distribution among DBH

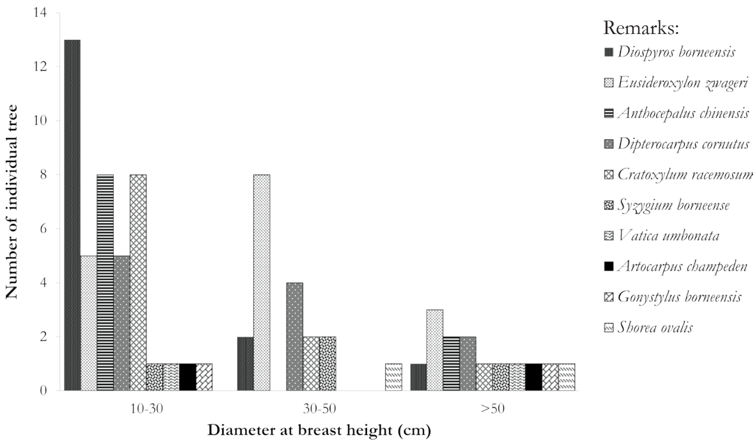


Figure 7. Eight species with individual trees above 50 cm DBH

D. Functional Group Composition

Twenty eight years after being affected by repeated fires in 1982/1983 and 1997/1998, light demanding species (pioneer and sub-climax species) reached up to 75% of the total population in the sample plot. Trees with DBH 10 – 20 cm and 20 – 30 cm are very common (Figure 6).

E. Spatial Distribution

The five most dominant species in the sample plot had clumped distribution at various degree of dispersion index. *Artocarpus anisophyllus*, *Macaranga gigantea* and *Vernonia arborea* indicated high clumping index, but *Melicope glabra* and *Pholidocarpus majadun* tend to be uniform. *Artocarpus anisophyllus* which indicated clumped distribution with highest dispersion index at 5.28 (black dot in Figure 6). The bigger bullet size expresses bigger tree DBH.

All surviving species distributed uniformly in the sample plot. Mapping surviving species, which are *Anthocephalus chinensis*, *Diospyros borneensis*, *Dipterocarpus cornutus*, *Eusideroxylon zwageri*, *Pholidocarpus majadun*, *Shorea ovalis Syzygium borneense*, *Vatica umbonata*, clearly showed that big trees with DBH >50 cm are found for each species, except *P. majadun* (Figure 7).

Observation in 2003 of the same sample plot found 188 of 254 species recruited in the 1.65 hectare plot and 148 species of 188 reach > 10 cm DBH (Simbolon, 2005). In the same plot with an additional 150 m^2 (1.8 hectare)

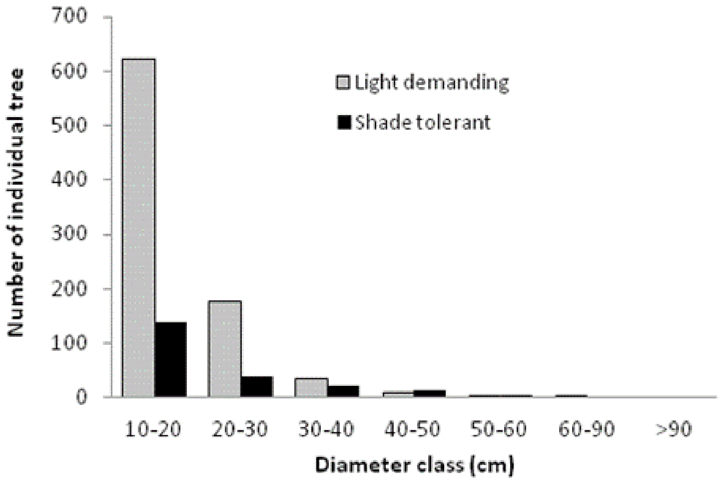


Figure 8. Tree population of light demanding and shade tolerant species in each diameter class

we found 191 of 273 species > 10 cm DBH. Referring to Simbolon (2005), during 1980 – 2003 188 species recruited in the secondary forest of Samboja Research Forest. However, 2011 observation found 191 species in the same plot. It means that stagnation species recruitment occurred during 2003 – 2011.

Euphorbiaceae had the highest species member contributed by two genera of *Macaranga* and *Mallotus*. Both *Macaranga* and *Mallotus* are generally pioneer species that characterize forest disturbance. The genus *Macaranga* is associated with intermediate to high level of disturbance and *Mallotus* is an indicator of low to intermediate disturbance (Slik, Kebler, & van Welzen, 2003). High population of *Macaranga* species regenerated in the secondary forest after being affected by repeated fires indicate that high level disturbance occurred in this area.

Furthermore, according to Slik et al. (2003), *Macaranga* recruit only after disturbance and they were found immediately after fire and until at least 25 years. In the sample plot of Samboja Research Forest 13 years after the second fire, *Macaranga*, particularly *M. gigantea* occupied the area, even as major species indicated by the highest IVI 35.3. The other seven species of *Macaranga* grew as minor species with a total IVI of 10.6.

The consequence of the high level disturbance in the sample plot of Samboja Research Forest is low survival of species. Only 36 of 90 species 5 – 10 cm DBH developed to >10 cm DBH during 2003 – 2011. Changing ecological conditions after fires, both biotic and abiotic may influence species survival. Unfortunately, this paper cannot identify the survival and surviving species due to unavailable of the species list of the 2003 survey.

Tree density in 2003 observation reached 45% of the pre-fire value (Simbolon, 2005), but rapidly increased to 100% during 2003 – 2011. *Macaranga gigantea* had the highest tree density in the sample plot, followed by *Vernonia arborea*. *Macaranga gigantea* was a minor species in the forest area before fire (Kartawinata et al., 2008), but colonized rapidly after the fires from 205 trees of 5 – 10 cm DBH and 35 trees of 10 – 20 cm DBH in 2003 survey (Simbolon, 2005) increased to 143 trees of 10 – 20 cm DBH and 24 trees of 20 – 30 cm DBH in 2011 survey. Increasing tree >10 cm DBH density It indicated that 70% of tree 5 – 10 cm DBH in 2003 observation survived up to >10 cm DBH. Suitable environment condition after repeated fires is the main factor that stimulates the high survival rate of secondary species such as *Macaranga gigantea*.

The rapid increase of tree species after fires was mostly characterized by species with high light preference, small stature, low wood density, large leaves and/or small seeds, as well

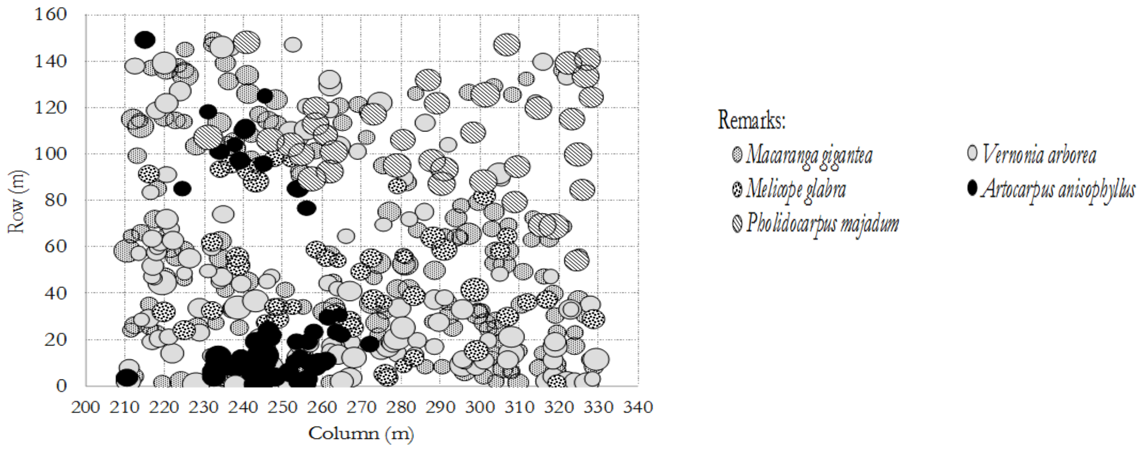


Figure 9. Map of tree position and DBH of the five most dominant species

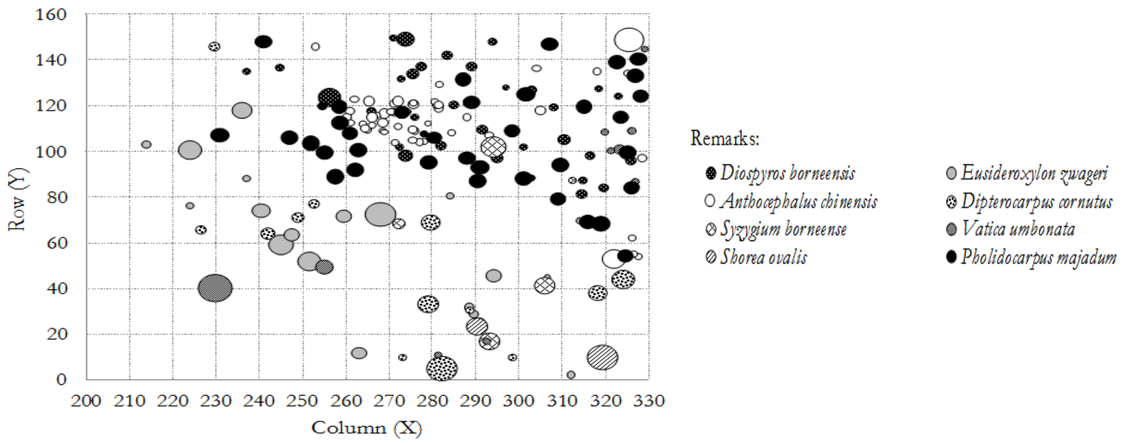


Figure 10. Map of tree position and DBH for six surviving species from repeated fires

as high sprouting capacity (Slik et al., 2010). Small seeds of *M. gigantea* disperse easily in the open area after fire by the wind (Blackham, Webb, & Corlett, 2014).

Two occurrences of fires reduced canopy cover in Samboja Research Forest significantly, then providing an open area with high penetration of light to forest floor and stimulating the seed bank of *M. gigantea* to germinate.

Referring to Kartawinata et al. (2008), changing dominance species that indicated by IVI occurred between 1981 and 2011 survey. Three highest IVI of 1981 survey were *Pholidocarpus majadun*, *Diospyros borneensis* and *Eusideroxylon zwageri*, but changed to *Macaranga gigantea*, *Vernonia arborea* and *Pholidocarpus majadumin* in the 2011 survey.

Pholidocarpus majadun is an endemic species of Borneo that is constantly dominant indicated by its relatively stable IVIs (15.2 and 13.0) and unaffected by repeated fires. This species was found particularly in the lowland and swamp forests, distributed uniformly in the sample plot. During 2003 – 2011, the tree population of *Pholidocarpus majadum* in the sample plot was relatively constant, from 37 (Simbolon, 2005) to 36 trees. Population dynamic occurred due to mortality and due to recruitment which resulted in the balance of the vegetation (Krisnawati, Wahjono, & Imanuddin, 2011). Most *Pholidocarpus majadun* survived in the sample plot and grew in the flat area that was not affected by fires (Simbolon, 2005). Moreover, vascular structure of the palm is a benefit for the tree to survive fire and was impacted by low mortality, less than 10% (Van Nieuwstadt & Sheil, 2005).

The second dominant species in the 2011 survey is a newly recruiting species of *Vernonia arborea*. This species was not found in the 1981 survey (Kartawinata et al., 2008), but found in both 2003 (Simbolon, 2005) and 2011 surveys. This species is categorized as light demanding with similar traits of *M. gigantea* (Van Nieuwstadt & Sheil, 2005). *V. arborea* is also recorded in the top ten dominant species in the burnt forest of Samboja and Sungai Wein that immediately colonized the burnt area at 2, 3 and 7 years after fires (Slik, Bernard, van Beek, Breman, & Eichhorn, 2008). The clumped dispersion pattern of *V. arborea* is related to the open area availability in the sample plot after fires.

Surviving species both from two and one fires are potential sources of seed in forest regeneration process. Remnant trees after fires play an important role as nuclei of forest regeneration (Balch, Brando, Nepstad, & Curran, 2013). All surviving species have individual trees above 50 cm DBH in 2011 survey. Individual trees with DBH of 10 to 50 cm of surviving species indicate that they recruited during 1983 – 2011.

Cratoxylum racemosum is not considered as survival from two occurrences of fires, because this species is recorded as recruiting species in the 2011 survey. However, it was found individual tree above 60 cm DBH in the plot. The individual tree may be regenerated after the first fire and survived the second fire. This species is categorized as a fast growing species. Study in Malaysia found that diameter increment of *Cratoxylum arborescens* seedling which is the same genus to *Cratoxylum racemosum* is 0.276 mm per week or about 1.5 cm per year (Mojiol, Wahyudi, & Nasly, 2014).

In the other hand, there were no *Pholidocarpus majadum* trees above 60 cm DBH, because this species is a member of Arecareae family with DBH ranged from 20 – 40 cm which is relatively constant from young to mature tree; but, tree height is used as survival indicator.

Anthocephalus chinensis grows in the area that has not been impacted by fire then develops as source of seeds of new individual trees that currently regenerating in the sample plot. This species is typically pioneer light is the most important factor, but large individual tree sometime can be found in primary rainforest (Verburg & van Eijk-Bos, 2003). Based on the current DBH of about 10 – 15 cm and growth rate of about 2 cm per year (Krisnawati, Kallio, & Kanninen, 2011), most individual trees are considered regenerated after the second fire. Uniform distribution of the species is a high relationship to availability of environmental condition in the plot. *Anthocephalus chinensis* was distributed in the flat area in the sample plot. High potential seed germination encourages certain species to survive. Fresh seeds of *Anthocephalus chinensis* give about 80% germination (Krisnawati, et al., 2011).

Diospyros borneensis is also recorded as survived species after forest fire at Bukit Soeharto education forest, East Kalimantan, with and without sprouts for 10 – 20 cm DBH (Delmy, 2001). Two DBH classes of 10 – 20 cm DBH and 20 – 30 cm DBH were found in the sample plot. Uniform distribution, but tend to be random at index of dispersion 0.07 which is related to the dispersal mode by animals, size of fruit that is categorized as medium, about 4.5 cm diameter and type of fruit that usually solitary but contain many seeds (Seidler & Plotkin, 2006)

Dipterocarpus cornutus, *Shorea ovalis* and *Vatica umbonata* are important Dipterocarp species that produce good quality timber that survived the fires. The capacity of *Dipterocarpus cornutus* to produce re-sprouting reach up to 100% in 9 – 10 months after fire; bark thickness of *Shorea ovalis* influence the persistency of species from fire. Both *Dipterocarpus cornutus* and *Shorea ovalis* seeds are wind dispersed that is highly random depend on the wind direction and velocity.

Different from the other Dipterocarp members, *Vatica umbonata* seed is wingless and dispersed by squirrel (Phillipps, 2016).

Eusideroxylon zwageri is a native species in Sumatera and Kalimantan that reported to be almost extinct (vulnerable in IUCN Red List), prominent species that survived with and without sprouts, can produce sprouts easily and resistant to fire (Delmy, 2001). Resprouting capacity now is widely recognized as a key functional trait of woody plants (Clarke et al., 2013). This species is categorized as slow growing tree with growth rate of about 0.5 cm per year. Tree diameter of *Eusideroxylon zwageri* in the sample plot in 2011 survey was mostly above 20 cm DBH and was distributed randomly with water and porcupines as potential dispersal agent. As reported by Kartawinata (1978), naturally regenerated seedlings are usually restricted to the area near seed parents and poor seedlings regeneration in logged-over forests. High level of sprouting capacity shows the persistence of individual tree from disturbance (Van Nieuwstadt & Sheil, 2005). High wood density of *Eusideroxylon zwageri*, 1.04 g cm-3 and bark thickness up to 9 cm (Martawijaya, Kartasujana, Kadir, & Prawira, 1992) contribute to the persistence from fire (Delmy, 2001; Van Nieuwstadt & Sheil, 2005).

All trees 10 – 20 cm and 20 – 30 cm DBH assumed to be new recruits after the second fire of 1997/1998; 50% of them came from *Macaranga gigantea* and *Vernonia arborea*; 80% of tree < 30 cm DBH is light demanding species. In opposite, tree >30 cm DBH dominated by shade tolerant species 65% for 30 – 50 cm DBH and 95% for >50 cm DBH.

Individual trees 30 – 50 cm DBH were considered to be regenerated after the first fire that survived after the second fire. Species richness in the sample plot indicates balance among light demanding and shade tolerant, but tends to be higher in species richness of shade tolerant species for larger diameter (>50 cm).

The current tree compositions indicate that two major fires in lowland mixed Dipterocarp forest caused high impact on tree mortality, particularly trees with less than 40 cm in diameter. However, highest recruitment occurred for some light demanding species that colonize immediately in the burnt area. Shade-tolerant species tend to be resistant fire better than light-demanding species. The existence of some individual trees above 50 cm DBH is evidence that those trees had affected by fire, but have capability to survive. In balance, species richness changes between light demanding and shade tolerant species of smaller trees less than 40 cm DBH indicate that during the succession process, some light demanding species colonize the open area and form canopy closure while the seed of shade tolerant species from the remnant forest start to regenerate under the canopy. However, increasing diversity of shade tolerant species above 40 cm DBH indicate that the individual tree species that survived from the second fire of 1997/1998 actually had recruited after the first fire of 1982/1983. Unaffected by fires due to located in the swampy areas in the plot such as *Pholidocarpus majadun*, *Anthocephalus chinensis* and *Diospyros borneensis* perhaps as survival factor of species. Survived shade tolerant species from fire plays an important role as source of seed in forest regeneration. However, some shade tolerant species contain limited number of individual trees, even single individual tree or less than 5 trees in each species. The single tree is vulnerable to local extinction due to various factors. Martinez-Garza and Howe (2003) suggested that 1 – 5 individual in a forest fragment less than 10 hectares area is still far from minimum viable population value.

IV. CONCLUSION

Twenty eight years after initial fire or thirteen years after the second fire, Euphorbiaceae was found as dominant family with highest number of tree population, genus and species in the sample plot of Samboja Research Forest. Family dominance was changed from Dipterocarpaceae before fire 1982/1982. *Macaranga gigantea* a light demanding pioneer species member of Euphorbiaceae is the most dominant species, followed by *Vernonia arborea* belong to Asteraceae. Low sapling species survival occurred during 2003 – 2011 due to changing of ecological conditions after repeated fires. Smaller trees <30 cm DBH dominated by light demanding pioneer species up to 80%, but 65% of tree 30 – 50 cm DBH and 95% of trees >50 cm DBH is shade tolerant species. All surviving species from both 1982/1983 and 1997/1998 fires distributed uniformly in the sample plot, but the most dominant species had clumped distribution due to similar ecological condition requirement after fire. Based on the current species composition, we identified that the secondary forest of Samboja Research Forest is in its early succession dominated by pioneer species with high risk to fire. Protecting the area from disturbance, assisting natural regeneration while monitoring the dominant species and enrichment planting of late-successional species that were lost due to the fires are recommended activities to accellerate species composition recovery.

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REFERENCES

Baeza, M. J., Valdecantos, A., Alloza, J. A., & Vallejo, V. R. (2007). Human disturbance and environmental factors as drivers of long-term post-fire regeneration patterns in Mediteranean forests. *Journal of Vegetation Science*, *18*, 243–252.

Balch, J. K., T.J., M., Brando, P. M., Nepstad, D., & Curran, L. M. (2013). Effects of high-frequency understoreyfires on woody plant regeneration in southeastern Amazonian forests. *Philosophical Transactions of the Royal Society B*, *368*, 20120157. doi:10.1098/rstb.2012.0157

Blackham, G. V., Webb, E. L., & Corlett, R. (2014). Natural regeneration in a degraded tropical peatland, Central Kalimantan, Indonesia: Implications for forest restoration. *Forest Ecology and Management, 324*, 8–15.

Clarke, P. J., Lawes, M. J., Midgley, J. J., Lamont, B. B., Ojeda, F., Burrows, G. E., … Knox, K. J. E. (2013). Resprouting as a key functional trait: how buds, protection and resources drive persistence after fire. *New Phytologist*, *197*(1), 19–35.

Clement, F. E. (1916). *Plant succession: an Analysis of the development of vegetation*. Washington: Carnegie Institute of Washington.

Curtis, J. T. (1959). *The vegetation of Wisconsin: An ordination of plant communities*. Madison, WI., USA: University of Wisconsin Press.

Delmy, A. (2001). Fire resistance of tree species in Bukit Soeharto Education Forest, East Kalimantan, Indonesia. In S. Kobayasi, et al. (Eds.), *Rehabilitation of Degraded Tropical Forest Ecosystems. Workshop Proceeding 2-4 November 1999*. Bogor: Centre for International Forestry Research.

Kartawinata, K. (1978). Biological changes after logging in lowland dipterocarp forest. In *Proceedings of the Symposium on the Long-term Effects of Logging in Southeast Asia*, *BIOTROP Special Publication* (pp. 27–34). Bogor, Indonesia.

Kartawinata, K., Purwaningsih, Partomihardjo, T., Yusuf, R., Abdulhadi, R., & Riswan, S. (2008). Floristic and a structure of low land Dipterocarp forest at Wanariset Samboja, East Kalimantan, Indonesia. *Reinwartia*, *12*(4), 301–323.

Kim, D., & Arthur, M. A. (2014). Changes in community structure and species-landform relationship after repeated fire disturbance in an oak-dominated temperate forest. *Ecological Research*, *29*, 661–671. doi:10.1007/s11284-014-1157-y.

Krisnawati, H., Kallio, M., & Kanninen, M. (2011). *Anthocephalus cadamba* Miq.: *Ekologi,* *silvikultur dan produktivitas*. Bogor: Center for International Forestry Research.

Krisnawati, H., Wahjono, D., & Imanuddin, R. (2011). Changes in the species composition, stand structure and aboveground biomass of a lowland of Dipterocarp forest in Samboja, East Kalimantan. *Journal of Forestry Research*, *8*(1), 1–16. doi:10.20886/ijfr.2011.8.1.1-16.

Ludwig, J. A., & Reynolds, J. F. (1988). *Statistical ecology: A primer on methods and computing*. Canada: John Wiley & Sons Inc.

Martawijaya, A., Kartasujana, I., Kadir, K., & Prawira, A. S. (1992). *Indonesia wood atlas Volume II*. Bogor: Forest Products Research and Development Centre, Agency for Forest Research and Development Agency, Department of Forestry.

Martinez-Garza, C., & Howe, H.F. (2003). Restoring tropical diversity: beating the time tax on species loss. *Journal of Applied Ecology*, *40*, 423–429.

Mojiol, A. R., Wahyudi, & Nasly, N. (2014). Growth performance of three indigenous tree species (*Cratoxylum arborescens* Vahl. Blume, *Alstonia spathulata* Blume, and *Stemonurus scorpioides* Becc.) Planted at Burned Area in Klias Peat Swamp Forest, Beaufort, Sabah, Malaysia. *Journal of Wetland Environmental Management*, *2*(1), 66–78.

Nasi, R., Dennis, R., Meijaard, E., Applegate, G., & Moore, P. (2001). Forest fire and biological diversity. Retrieved from http://www.fao.org/docrep/004/y3582e/y3582e08.htm.

Peterson, D. W., & Reich, P. B. (2008). Fire frequency and tree canopy structure influence plant species diversity in a forest-grassland ecotone. *Plant Ecology*, *195*, 5–16. doi:10.1007/s11258-007-9270-4.

Phillipps, Q. (2016). *Phillipp's field guide to the mammals of Borneo: Sabah, Sarawak, Bunei and Kalimantan*. Princenton and Oxford: Princenton University Press. Retrieved from https://books.google.co.id/books?isbn=0691169411

Pyke, D. A., Brooks, M. L., & D'Antonio, C. (2010). Fire as a restoration tool: a decision framework for predicting the control or enhancement of plants using fire. *Restoration Ecology*, *10*(3), 274–284.

Riswan, S., Kenworthy, J. B., & Kartawinata, K. (1985). The estimation of temporal processes in tropical rain forest: A study of primary mixed dipterocarp forest in Indonesia. *Journal of Tropical Ecology*, *1*, 171–182.

Seidler, T. G., & Plotkin, J. B. (2006). Seed dispersal and spatial pattern in tropical trees. *PLos Biology*, *4*(11), e344. doi:10.1371/journal.pbio.0040344.

Simbolon, H. (2005). Dinamika hutan Dipterocarp campuran Wanariset Samboja, Kalimantan Timur setelah tiga kali kebakaran tahun 1980 – 2003. *Biodiversitas*, *6*(2), 133–138.

Slik, J. W. ., Bernard, C. S., van Beek, M., Breman, F. C., & Eichhorn, K. A. O. (2008). Tree diversity, composition, forest structure, and aboveground biomass dynamics after single and repeated fire in a Bornean rain forest. *Oecologia*. *158*(3),579 doi:10.1007/s00442-008-1163-2.

Slik, J. W. F., Breman, F. C., Bernard, C., van Beek, M., Cannon, C. H., Eichhorn, K. A. O., & Sidiyasa, K. (2010). Fire as selective force in a Bornean tropical everwet forest. *Oecologia*, *164*, 841–849. doi:10.1007/s00442-010-1764-4

Slik, J. W. F., Kebler, P. J. A., & van Welzen, P. C. (2003). *Macaranga* and *Mallotus* species (Euphorbiaceae) as indicators for disturbance in mixed lowland Dipterocarp forest of East Kalimantan, Indonesia. *Ecological Indicators*, *2*, 311–324.

Van Nieuwstadt, M. G. L., & Sheil, D. (2005). Drought, fire and tree survival in a Borneo rain forest, East Kalimantan, Indonesia. *Journal of Ecology*, *93*, 191–201.

Verburg, R., & van Eijk-Bos, C. (2003). Effects of selective logging on tree diversity, composition and plant functional type patterns in a Bornean rain forest. *Journal of Vegetation Science*, *14*, 99–110.

DYNAMIC PROJECTION OF CLIMATE CHANGE SCENARIOS ON ABOVEGROUND CARBON STORAGE OF TROPICAL TREES IN WEST PAPUA, INDONESIA

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DYNAMIC PROJECTION OF CLIMATE CHANGE SCENARIOS ON ABOVEGROUND CARBON STORAGE OF TROPICAL TREES IN WEST PAPUA, INDONESIA. Through photosynthetic activities, tropical forest ecosystems capture and store the most significant carbon emissions in the form of biomass compared with other types of vegetation, and thus play a highly crucial part in dealing with climate change. However, such important role of tropical forest is very fragile from extreme changes in temperature and precipitation, because carbon storage in forest landscape is strongly related to those climate variables. This paper examines the impacts of future climate disturbances on aboveground carbon storage of three tropical tree species, namely *Myristic*a sp., *Palaquium* sp., and *Syzygium* sp. through "what if" scenarios evaluation using Structural Thinking and Experimental Learning Laboratory with Animation (STELLA). Results highlighted that when the dynamic simulation was running with five IPCC's climate change scenarios (Constant year 2000 concentrations, B1, A1T, A2, and A1F1) for 200 years simulation period, then moderate climate change scenarios occured, such as B1 and A1T, would have already caused significant statistical deviation to all of those tree species. At the worst level of A1F1, the 4°C temperature was coupled with 20% reduction in precipitation. *Palaquium* sp. showed the highest reduction of aboveground carbon storage with about 17.216% below its normal value. This finding implies the negative climate feedbacks should be considered seriously to ensure the accuracy of long term forest carbon accounting under future climate uncertainty.

Keywords: Climate change, aboveground carbon storage, West Papua, STELLA

PROYEKSI DINAMIS BERBAGAI SKENARIO PERUBAHAN IKLIM TERHADAP SIMPANAN KARBON DI ATAS PERMUKAAN TANAH PADA BERAGAM JENIS POHON TROPIS DI PAPUA BARAT, INDONESIA. Melalui fotosintesis, ekosistem hutan menangkap dan menyimpan emisi karbon dalam bentuk biomassa yang paling besar dibandingkan dengan jenis vegetasi lain, dan memainkan peran yang sangat penting dalam menangani perubahan iklim. Namun demikian, peran penting tersebut secara signifikan dapat terganggu oleh perubahan temperatur dan curah hujan yang ekstrem karena penyimpanan karbon di lanskap hutan sangat terkait dengan variabel iklim tersebut. Tulisan ini mempelajari dampak gangguan iklim di masa depan pada penyimpanan karbon di atas tanah pada tiga spesies pohon tropis, yaitu Myristica *sp.,* Palaquium *sp., dan* Syzygium *sp. melalui evaluasi skenario "bagaimana jika" berbasis STELLA. Hasil penelitian menunjukkan bahwa ketika simulasi dinamis dijalankan mengikuti lima skenario perubahan iklim oleh IPCC untuk periode simulasi 200 tahun, terlihat bahwa skenario moderat, seperti B1 dan A1T, telah menyebabkan simpangan yang signifikan untuk ketiga spesies pohon tropis tersebut. Pada skenario terburuk A1F1 (kenaikan suhu 4°C ditambah dengan pengurangan 20% curah hujan), pohon dari spesies* Palaquium *sp. memperlihatkan tingkat penurunan tertinggi pada simpanan karbon di atas tanah dengan sekitar 17,216% kurang dari nilai normalnya. Hal ini menunjukkan bahwa umpan balik negatif dari perubahan iklim harus diperhitungkan untuk memastikan keakuratan penghitungan karbon hutan jangka panjang di bawah ketidakpastian iklim di masa depan.*

Kata kunci: Perubahan iklim, simpanan karbon diatas tanah, Papua Barat, STELLA

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I. INTRODUCTION

It has been widely recognized that carbon dioxide (CO_2) constitutes for more than half of the total anthropogenic greenhouse gasses emissions. Through photosynthesis procedures, tropical forest ecosystems capture and store the most significant carbon emissions in the form of biomass compared with other types of vegetation, and thus it plays a highly crucial part in dealing with climate change. As reported by Sha et al. (2015), about 55% of annual net primary production of biomass across the globe is estimated to take place in the tropics. Nevertheless, some authors, such as Ricker, Gutiérrez-García, and Daly (2007); Dai et al. (2014); and Ma et al. (2014), have noted that such important role of tropical forest is very vulrnerable to extreme changes in temperature and precipitation since carbon storage in forest landscape is much related to those climate variables. Dai et al. (2014) also added how the changes in temperature and/or precipitation will drive carbon dynamics in forest ecosystem.

Nowadays, what is alarming is that the earth's mean temperature has already increased by 0.6°C over the last 100 years, and that further climate change may raise global temperature within the next century by another 4°C (Intergovernmental Panel on Climate Change [IPCC], 2007). Therefore, there is a need to assess how the carbon dynamics of tropical trees may react to climate change as the report has also suggested a negative impact of warming in tropical forests from decreased photosynthetic activity.

Previously, some researchers have carried out studies related to climate influence on carbon accumulation in forest ecosystems. Hunter (2015) assessed the influences of temperature and rainfall on carbon stocks across Northeastern part of New South Wales, Australia, while Limbu and Koirala (2017) examined the climate influence at different altitudinal gradients on both below and aboveground carbon storage. Recently, Ma et al. (2014) predicted the impacts of climate change on aboveground carbon storage rate in Northeastern China. Stinziano and Way, (2014) evaluated the effect of rising temperature on boreal forest. Meanwhile, climate sensitivity of Mediterranean landscape has been investigated by Touchan, Shishov, Meko, Nouiri, and Grachev (2012). Although all of those studies provide important information on the relation between changing climate variables and carbon storage, however, the dynamics of aboveground carbon storage of tropical trees in the eastern part of Indonesia under climate change scenarios are still unclear. Many other researchers had also examined how the carbon stock and biomass accumulation were assessed either using terrestrial or remotely sensed data (Jaya et al., 2012, Achmad, Jaya, Saleh, & Kuncahyo, 2013; Jaya, 2014).

According to Dominati, Patterson, and Mackay (2010), insufficient knowledge of carbon storage as ecosystem dynamic flow processes may result in the absence of a systematic and flexible method to manage and plan the ecosystem, so that temporal study and analysis of dynamic change of ecosystem service is necessary. Furthermore, Dean, Roxburgh, and Mackey (2003) and Oni, Dillon, Metcalfe, and Futter (2012) contend that dynamic flow modeling and its corresponding analyses are essential in providing a baseline and "what if" scenarios for evaluating effects related to climate disturbances. This paper examines the impacts of future climate disturbances on aboveground carbon storage of three tropical tree species, namely *Myristica* sp., *Palaquium* sp. and *Syzygium* sp. through "what if" scenarios evaluation using Structural Thinking and Experimental Learning Laboratory with Animation (STELLA).

II. MATERIAL AND METHOD

A. Study Site

As depicted in Figure 1, this study was conducted in a concession forest area managed by PT. Manokwari Mandiri Lestari in Teluk Bintuni Regency, West Papua (1057'50"-3011'26" S; 132044'59"-134014'49" E).

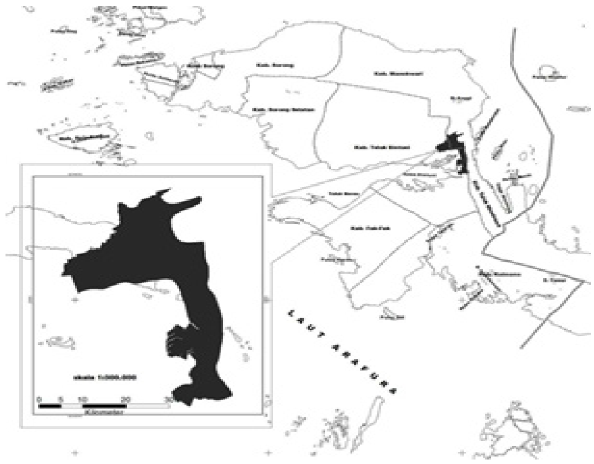


Figure 1. Research site map

This research area is mainly hilly and located about 500 meters above sea level with average humidity approximately 85%. There are three main soil types in the area, namely alluvial, gleysol and podzolic.

B. Model Conceptualization, Calibration and Projection

As shown in Figure 2, dynamic model structure for simulating relationship between local climate variables and carbon storage in this study was developed using STELLA 9.12, which is principally an object-oriented modeling and simulation software. Algorithm details of this dynamic model are shown in Appendix 1. Conceptually, in this study there are two step sectors in the whole process of carbon sequestration flow structure, which are carbon capture and carbon storage that can last for a long period. Carbon capture refers to the uptake of CO_2 from the atmosphere through photosynthetic mechanism and its conversion to biomass, whilst carbon storage refers to the preservation of carbon as biomass in the components of corresponding trees (Sha et al., 2015).

Firstly, in carbon capture sector, through photosynthesis, vegetation converts carbon from the atmosphere to carbohydrate and stores it in different tree organs. This process of carbon capture is related to the process of tree growth (Sha et al., 2015), and it is influenced by climatic factors, particularly temperature and precipitation rate (Theurillat & Guisan, 2001; Laubhann, Sterba, Reinds, & Vries, 2009; Allen et al., 2010). In this study, the value of tree growth as a function of time was adjusted based on the value of annual increment calculated by Wahyudi and Anwar (2013), in which *Palaquium* sp. was grouped into harvested commercial species, while both *Myristica* sp. and *Syzygium* sp. were grouped into other commercial un-harvested species, as depicted in Table 1. Although in their study, Wahyudi and Anwar (2013) have used the term Mean Annual Increment (MAI), however, according to several other studies such as Vanclay (1994), Avery and Harold (2002), and Pretzsch (2009), it seems that the term Periodic Annual Increment (PAI) is more relevant to represent the growth of tree species in natural forest because basically there is no age information for those natural tree species.

Obtained PAI data, as illustrated in Table 1, were then used to estimate the tree growth period (TGP) for each DBH class. For the beginning of the growth period, due to the unavailability of PAI data for DBH class less than 10 cm, the simulation at year 0 was set using initial DBH of 10 cm. From that point forward, TGP was calculated by dividing the interval of each DBH class (cm) with its corresponding PAI (cm/year) as depicted in Table 2.

Afterwards, biomass accumulation into the

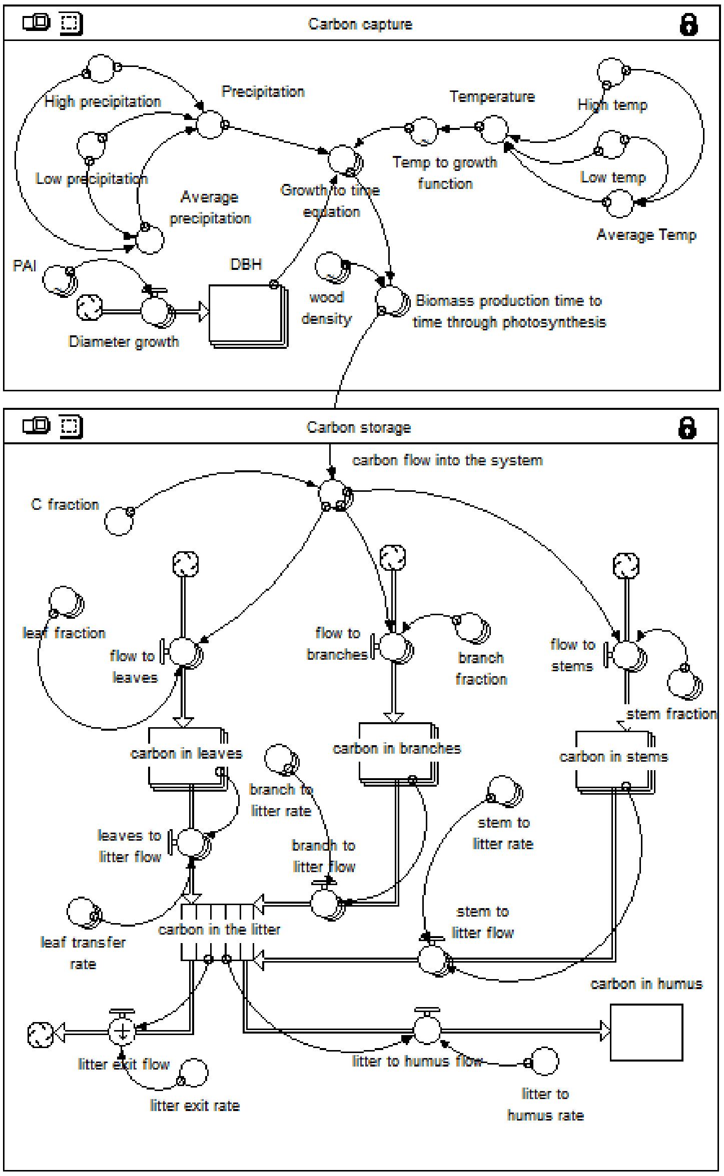


Figure 2. Model structure for simulating climate variables and carbon flows

system through photosynthetic activity was calibrated using locally developed allometric formula (Equation 1), which was specifically designed for mixed tree species in the research area by Maulana, Wibisono, and Utomo (2016).

$$Log(TAGB) = -0.267 + 2.23 Log(DBH) + 0.649 Log(WD) \ldots(1)$$

where:

TAGB = total aboveground biomass (kg/tree)
DBH = diameter at breast height (cm)
WD = wood density or specific gravity (gr/cm^3)

In the meantime, in order to obtain values of wood density (WD) and biomass fractions allocated to leaves, branches and stems, harvest method was applied to 31 trees of *Myristica* sp., *Palaquium* sp. and *Syzygium* sp. Compared to wood density values from Soerianegara and Lemmens (1993), and Lemmens, Soerianegara, and Wong (1995), results of measurements in this study is shown in Figure 3. It illustrates a highly rational wood density for each species since it is mentioned that the range of wood density for *Myristica* sp., *Palaquium* sp., and *Syzygium* sp. are 0.40-0.65 gr/cm^3, 0.45-0.51 gr/cm^3, 0.56-0.83 gr/cm^3 respectively.

Moving on to the second sector of

Table 1. Tree growth

DBH Class (cm)	*Palaquium* sp.	*Myristica* sp.	*Syzygium* sp.
	PAI (cm/year)	PAI (cm/year)	PAI (cm/year)
10-19	0.2158	0.2108	0.2108
20-29	0.3408	0.3458	0.3458
30-39	0.4058	0.4208	0.4208
40-49	0.4108	0.4358	0.4358
50-59	0.3558	0.3908	0.3908
>60	0.2408	0.2858	0.2858

Source: Wahyudi and Anwar (2013)

Table 2. Calculation of Tree Growth Period (TGP) and its simulation time step

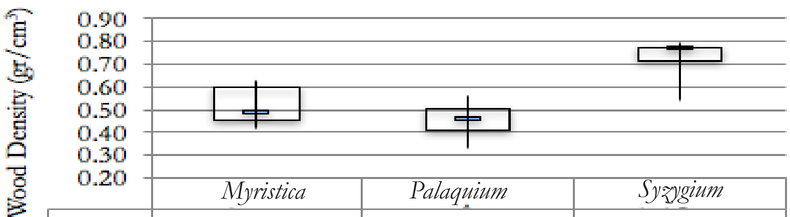
DBH class		10-19 cm	20-29 cm	30-39 cm	40-49 cm	50-59 cm	>60cm
TGP calculation		(19-10)/PAI	(29-20)/PAI	(39-30)/PAI	(49-40)/PAI	(59-50)/PAI	
Palaquium sp.	TGP	42 years	26 years	22 years	22 years	25 years	≥ year 142
	Time step	year 1 to 42	year 43 to 69	year 70 to 92	year 93 to 115	year 116 to 141	
Myristica sp.	TGP	43 years	26 years	21 years	21 years	23 years	≥ year 139
	Time step	year 1 to 43	year 44 to 70	year 71 to 92	year 93 to 114	year 115 to 138	
Syzygium sp.	TGP	43 years	26 years	21 years	21 years	23 years	≥ year 139

carbon storage, carbon influx is split in three directions, namely stems, branches and leaves. As depicted in Figure 4, result from destructive measurements to obtain biomass fraction for each species adapted from Maulana et al. (2016) have illustrated the major biomass storage in a tree, followed by branches and leaves. Meanwhile, carbon content in tree components was determined using biomass to carbon ratio value established by Hairiah and Rahayu (2007) that was 46%, so that carbon quantity in each component was defined by multiplying the dry weight of corresponding components by the percentage of carbon amount.

Calibration for carbon flow into the system and litter flow rate were conducted repeatedly until there was no significant difference between actual storage value approximation and dynamic modelling results based on the value of two samples t-test using MINITAB 14.0 software. In this study, actual carbon storage value approximation is defined as the value of total aboveground carbon stored in trees over time approached solely based on local allometric formula (Equation 1) using DBH adjusted by diameter growth periodic calculation and WD from field measurement. On the other hand, dynamic modeling carbon storage value is defined as the value of total aboveground carbon stored in tree over time calculated based on STELLA dynamic model structure as depicted in Figure 2.

Initial dynamic simulation was set based on climate time series data of perceived temperature and precipitation for the last decade (2005-2015) that were supplied by the National Climatic Data Center (NCDC) from its nearest climate station in Teluk Bintuni Regency, West Papua. The trends of these climate variables data are illustrated in Figure 5. According to these climatic trends, the annual range of temperature and precipitation in the research area were about 22.9°C to 31.5°C and 1042.7 mm/year to 3333.5 m/year respectively.

Subsequently, projections toward future probabilities of climate disturbances were



	Myristica	*Palaquium*	*Syzygium*
Average	0.49	0.46	0.77
Q1	0.45	0.41	0.72
Min	0.41	0.33	0.54
Max	0.63	0.56	0.80
Q3	0.60	0.50	0.78

Figure 3. Measured wood density

Table 3. Scenarios of future climate conditions at the end of 21st century (2090-2099)

Scenario	Temperature increase (°C)		Precipitation change
	Best estimate	Likely range	Average
Constant year 2000 concentrations	0.6	0.3-0.9	-20%
B1	1.8	1.1-2.9	
A1T	2.4	1.4-3.8	
A2	3.4	2.0-5.4	
A1FI	4.0	2.4-6.4	

Source: Intergovernmental Panel on Climate Change [IPCC] (2000)

conducted using scenarios described in Special Report on Emission Scenarios (SRES) by Intergovernmental Panel on Climate Change [IPCC] (2000). Details on climate scenarios involved in this study are depicted in Table 3. Overall, according to Intergovernmental Panel on Climate Change [IPCC] (2000), the first scenario (year 2000) is constant assumes that greenhouse gases concentration is held fixed at year 2000 levels. Hence, this scenario put the lowest projection of temperature increase at 0.6°C. The B2 scenario describes a world with less rapid economic and population development due to increasing attention to environmental sustainability. The A1T scenario illustrates a future world with rapid introduction of new technologies of non-fossil energy sources. The A2 scenario considers fragmented technological and economic development. Lastly, The A1FI scenario puts more emphasis on the intensive development of fossil fuel based industries, so that this scenario gets the highest estimate of temperature increase of 4°C. In the meantime, as suggested in Gardner and Urban (2003), in order to examine the impact of future climate disturbances on carbon storage of each species, results from dynamic simulations based on IPCC scenarios were then compared to results of their dynamic modelling of actual carbon storage harnessing their percentage value of deviation (Equation 2), while statistically examined based on paired t-test mechanism.

$$S = 100 * \left(\frac{\sum_{i=1}^{n} D_i - \sum_{i=1}^{n} B_i}{\sum_{i=1}^{n} B_i} \right) \quad \text{.........................(2)}$$

where:

S = percentage value of deviation

B_i = dynamic modeling of actual carbon stored in tree-i

D_i = its projection based on IPCC scenario set in the dynamic model

n = number of observations

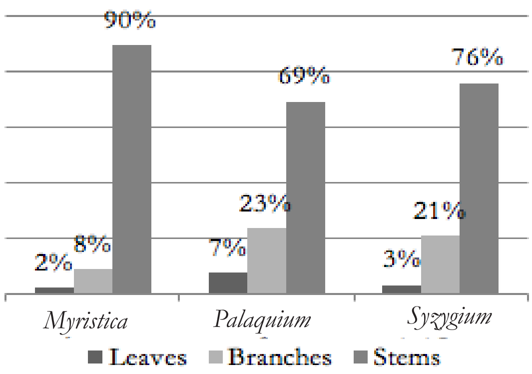


Figure 4. Observed biomass fraction (Source: adapted from Maulana et al., 2016)

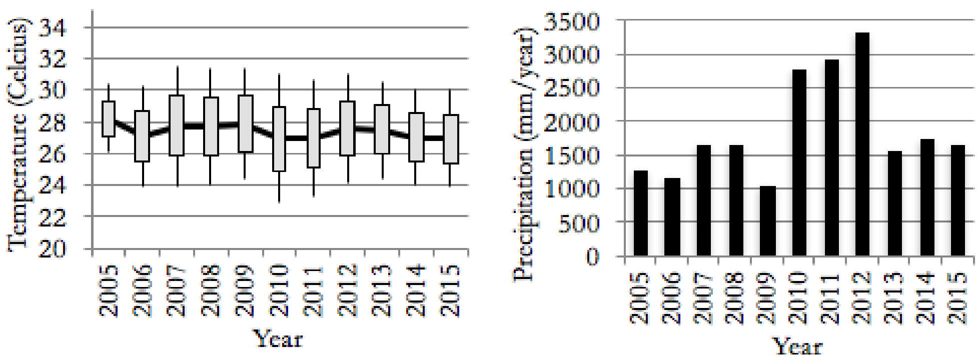


Figure 5. Baseline data for temperature and precipitation as observed by NCDC

III. RESULT AND DISCUSSION

A. Actual Approximation vs Dynamic Modeling of C Storage at Baseline Condition

To assess the accuracy and enhance projection confidence for future "what if" scenarios as described in Bugmann (2001) and Ford (2010), actual approximations of carbon storage for each species were initially evaluated against its corresponding dynamic modelling result set at baseline conditions. This evaluation is essential to show that there was no significant difference between actual carbon sequestered by the system and its dynamic estimation (Gardner & Urban, 2003; Ford, 2010).

In the previous study, the prototypes were also assessed by using some calculations for cost analysis. The result of the calculation for both prototypes is given in Table 4.

As depicted in Table 4, the result of t-test, shows that t-values are significantly below their t-table at 95% confidence interval; and P-values (P>0.05) also indicate weak evidence against the null hypothesis (H_0). This implies that H_0 (dynamic modelling is close to the actual approximation of carbon storage, expressing that for each species) are statistically accepted (Gardner & Urban, 2003). In addition, values of Pearson correlation test (r) between approximation and its corresponding dynamic modelling of actual storage for each species shows a very high and positive correlation. As illustrated in Figure 6, the overall trends of carbon storage for each species formed a common rough sigmoid shaped growth curve, showing that the carbon amount stored increases fast in their early age, while later this trend tends to gradually slow down due to the decrease in carbon capture.

Table 4. Statistical tests for actual approximation vs dynamic modeling of C storage

Species	Group comparison	t-test at 95% confidence interval						
		Mean	SE Mean	DF	t-table	t-value	p-value	r
Myristica sp.	Actual proxy	839	51	397	1.985	0.46	0.647	0.99
	Dynamic modeling	806	50					
Palaquium sp.	Actual proxy	754	45	397	1.985	0.47	0.639	0.99
	Dynamic modeling	725	44					
Syzygium sp.	Actual proxy	1019	60	397	1.985	0.48	0.634	0.99

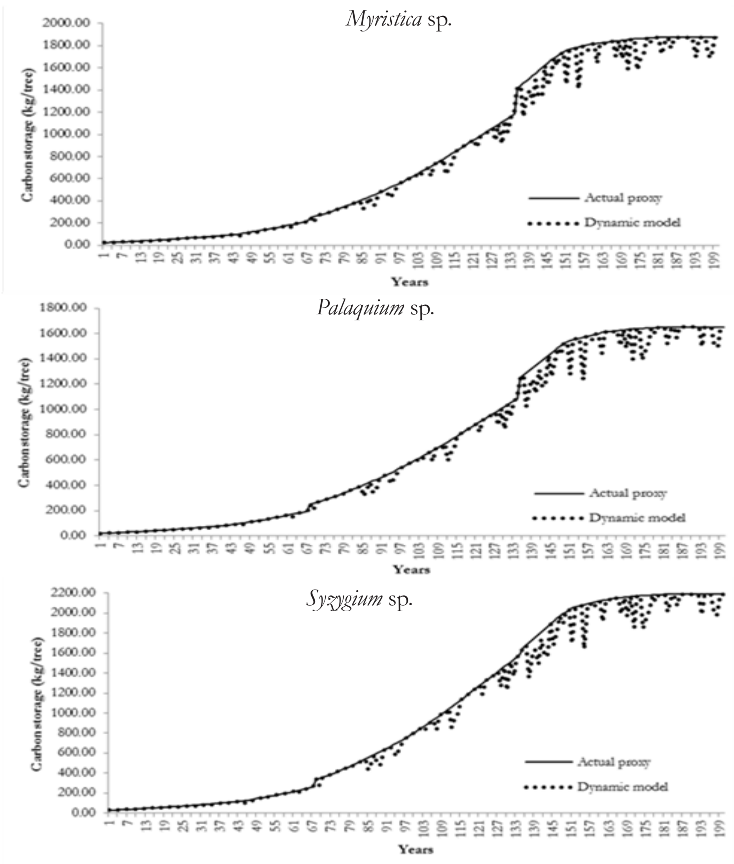


Figure 6. Actual approximation vs dynamic modeling of C storage at baseline condition

B. Dynamic Projections of Future C Storage Based on IPCC Scenarios

In general, as illustrated in Figure 7, 8 and 9, there were dynamic fluctuations of carbon storage for each species when climate parameters within the dynamic model were set following future scenarios as described in Intergovernmental Panel on Climate Change [IPCC] (2000). At first, the aboveground carbon storage for each tree species were relatively stable when the model was run based on the "constant year 2000 concentrations" scenario, where the assumption was a 0.6°C temperature increase and about 20% precipitation decrease. Nevertheless, from that point forward, the aboveground carbon stored in the system generally started to decrease when the climate parameters were adjusted to more extreme scenarios, namely B1, AIT, A2, and A1FI. This kind of fluctuation may occur since at warmer temperature and lower precipitation compared to normal condition, broadleaf trees tend to decrease their photosynthetic productivity while increase littering pace to sustain their metabolism equilibrium which eventually hamper their growth and reduce carbon storage capacity (Heimann & Reichstein, 2008; Omeja, Obua, Rwetsiba, & Chapman, 2012; Wang, Duan, & Zhang, 2012).

To sum up, the detailed projections of Intergovernmental Panel on Climate Change [IPCC] (2000) climate scenarios on carbon storage for each species from Figure 7, 8 and 9 are shown in Table 5. This table, apparently describes that future rise in temperature and decrease in precipitation rate will reduce carbon storage capacity for all species. Furthermore, climate change will cause the largest impact in scenario A1F1 where there is 4°C increase in temperature range coupled with 20% reduction in precipitation. At this scenario, aboveground carbon stored in the trees from species of *Myristica* sp., *Palaquium* sp., and *Syzygium* sp. will decrease approximately 17.213%, 17.216% and 16.062% respectively during 200 years of simulation period.

Figure 10 shows the projection of C storage, derived from Table 4. It is clearly shown that *Myristica* sp., *Palaquium* sp., and *Syzygium* sp. are becoming more vulnerable when climate scenario worsens. Moderate climate change scenarios, such as B1 and A1T, have already brought significant statistical deviation to all of those species. In addition to this, looking at

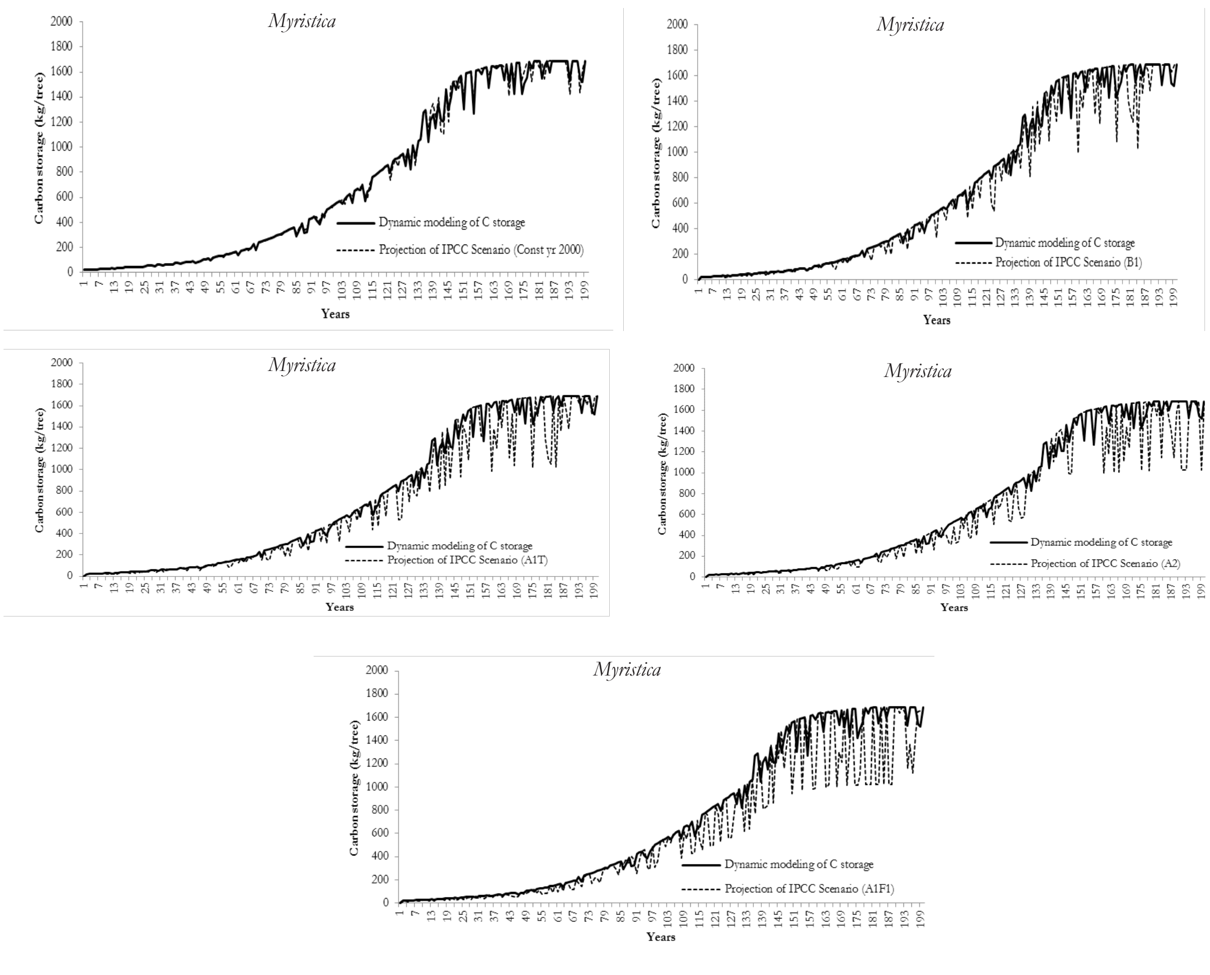


Figure 7. Projection of future climate change scenarios (Constant year 2000 concentrations, B1, A1T, A2, A1F1) on carbon storage of *Myristica* sp. for 200 years simulation period

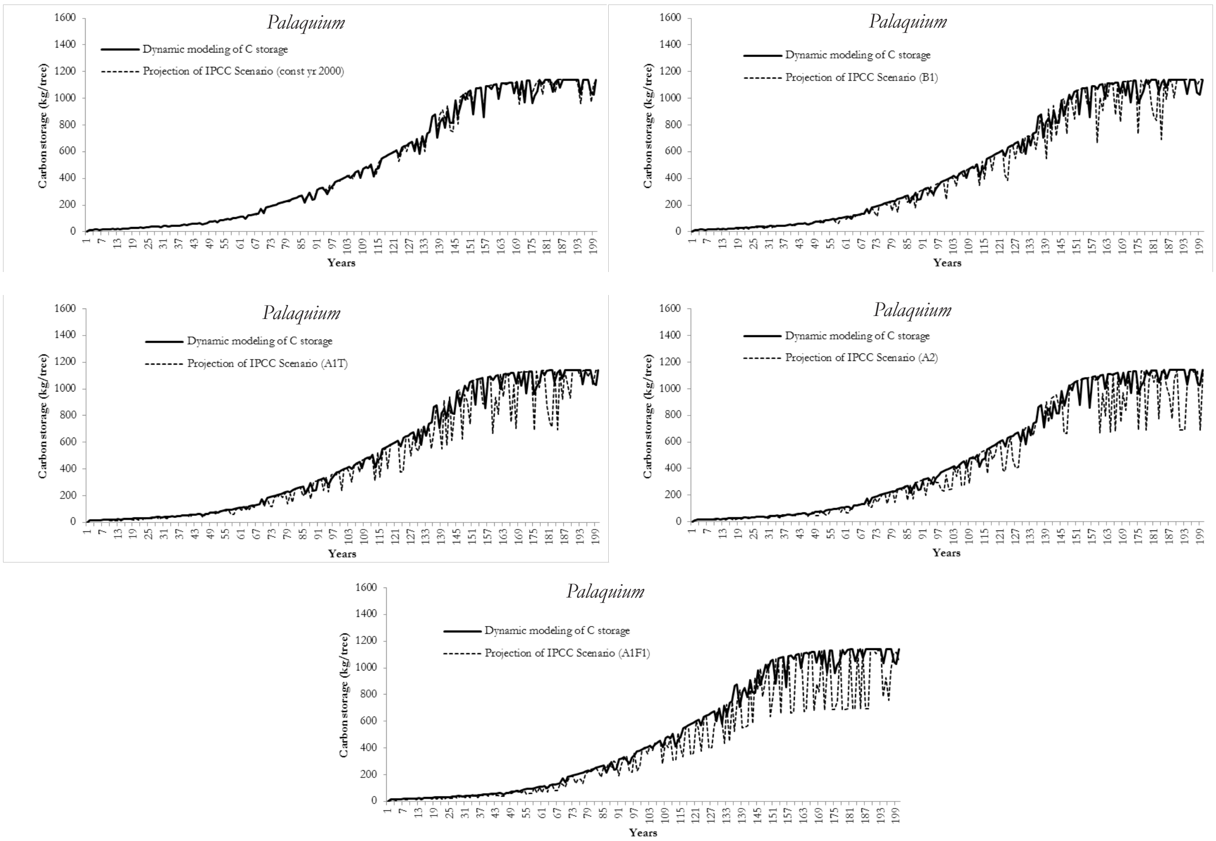


Figure 8. Projection of future climate change scenarios (Constant year 2000 concentrations, B1, A1T, A2, A1F1) on carbon storage of *Palaquium* sp. for 200 years simulation period

the more extreme climate scenario of A2 and A1F1, it seems that *Syzygium* sp. has the lowest decrease in carbon storage, while *Palaquium* sp. tends to produce the highest rate of decrease compared to the two other trees species. This finding is in agreement with several previous studies which have showed that the growth and productivity of many broadleaf trees with the lowest wood density value among their corresponding groups, is more vulnerable when temperature becomes warmer (Bennett et al., 2013; Coops & Waring, 2011; Subedi & Sharma, 2013; Hu, Su, Li, Li, & Ke, 2015). Taking into account of this notion, compared to *Myristica* sp. and *Syzygium* sp. (Table 5, Figure 3), *Palaquium* sp. has the lowest range of wood density with only 0.33 – 0.56 gr/cm^3 in contrast with *Syzygium* sp. that has the highest range of wood density with about 0.54 – 0.80 gr/cm^3.

This study noted that although the simulation findings may provide a feasible approach to analyze model dynamics, however, it should be kept in mind that the simulation aboveground carbon storage on various climate change scenarios are complex flow processes. The users may improve the accuracy of the dynamic model by appropriately considering the possible shortcomings, particularly in regard to tree growth calculation. Looking at the periodical annual increment of each tree species (Table 1), it seems that the growth rate are too slow and there is no obvious annual increment difference among them. The PAI for *Palaquium* sp. is only limited to 0.22 – 0.41 cm/year, while *Myristica* sp. and *Syzygium* sp. is about 0.21 – 0.43 cm/year. Those relatively small annual increments have also been reported by other studies, such as Santoso (2008), and Wahjono and Anwar (2008), who conducted measurements on permanent sample plots (PSPs) in 199

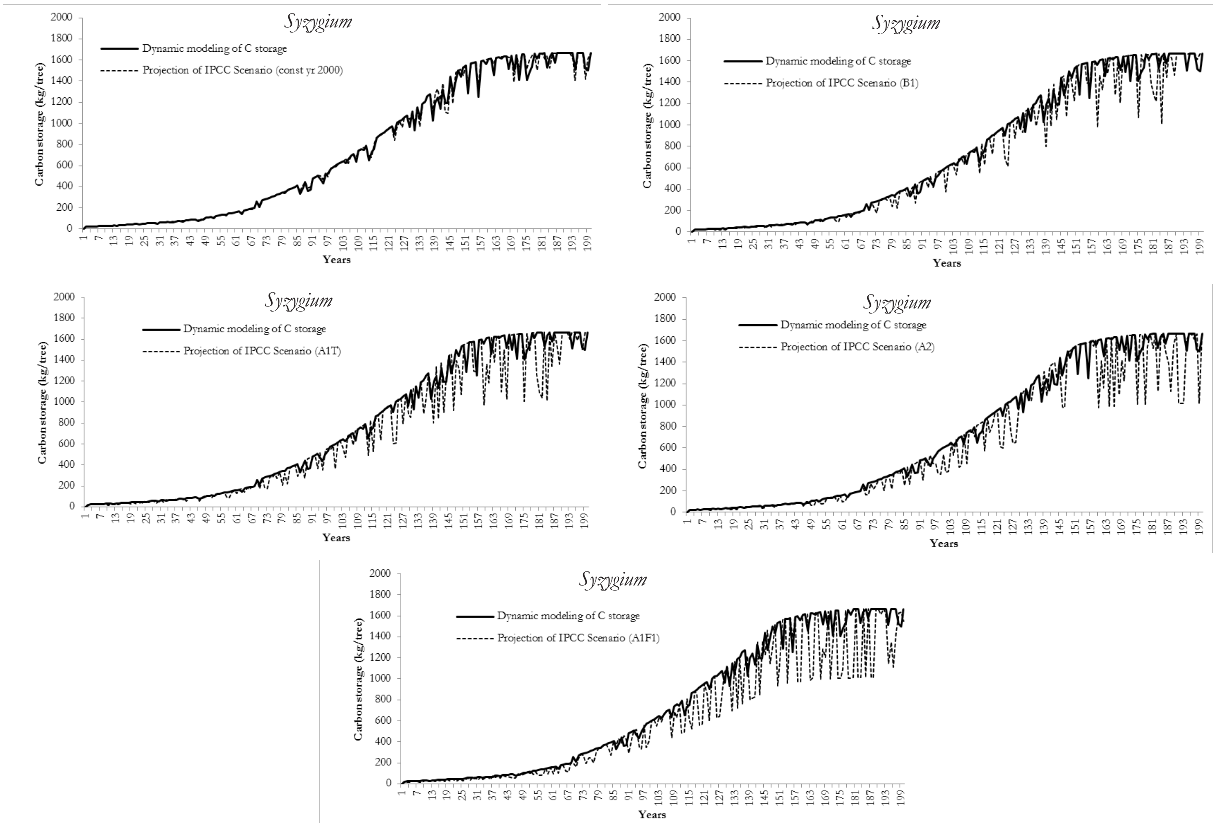


Figure 9. Projection of future climate change scenarios (Constant year 2000 concentrations, B1, A1T, A2, A1F1) on carbon storage of *Syzygium* sp. for 200 years simulation period

forest consessions across Indonesia. Although the use of tree growth data obtained from permanent sample plots (PSPs) of other studies, as mentioned in the methodology of this study, may inflict bias, however, this kind of approach should be considered as an acceptable alternative because detecting trends in tree growth over natural forest stands is not so simple (Bowman, Brienen, Gloor, Phillips, & Prior, 2013). In practice, measuring tree growth in PSPs of natural forest are indeed not only very time-consuming to conduct, but also highly logistically demanding since they are often located in remote species rich forets areas (Bowman et al., 2013; Weiskittel, Hann, Kershaw, & Vanclay, 2011).

IV. CONCLUSION

From the previous discussion, the following conclusions can be derived. When the dynamic simulation was run the five IPCC's climate change scenarios (Constant year 2000 concentrations, B1, A1T, A2, and A1F1) for a simulation period of 200 years, the aboveground carbon stored in tree species of *Myristica* sp., *Palaquium* sp., and *Syzygium* sp. will generally decrease. The moderate climate change scenarios, such as B1 and A1T, have already brought significant statistical deviation to all of those tree species. At the worst level of scenario A1F1 (4°C temperature increase coupled with 20% reduction in precipitation), the *Palaquium* sp. may suffer from the highest degree of reduction of aboveground carbon storage with about 17.216% below its normal value. The *Palaquium* sp. has the lowest range of wood density with only 0.33-0.56 gr/cm^3 compared to *Myristica* sp. and *Syzygium* sp. The study concludes that climate negative feedbacks should be considered to ensure the accuracy of long term forest carbon accounting under future climate uncertainties.

Table 5. C storage deviation based on IPCC SRES climate scenarios

Species		IPCC SRES Scenarios				
		Const yr 2000	B1	A1T	A2	A1F1
Myristica sp.	Deviation (S)	0.590%	-3.687%	-6.622%	-8.773%	-17.213%
	t-value at 95% CI	-1.70	3.25**	4.84***	5.04***	7.14***
	t-table (DF: 199; CI: 95%)	1.98	1.98	1.98	1.98	1.98
	p-value	0.090	0.001	<0.001	<0.001	<0.001
Palaquium sp.	Deviation (S)	0.589%	-3.687%	-6.622%	-8.777%	-17.216%
	t-value at 95% CI	-1.72	3.29**	4.90***	5.13***	7.23***
	t-table (DF: 199; CI: 95%)	1.98	1.98	1.98	1.98	1.98
	p-value	0.086	0.001	<0.001	<0.001	<0.001
Syzygium sp.	Deviation (S)	0.590%	-3.686%	-6.621%	-8.776%	-16.062%
	t-value at 95% CI	-1.71	3.32**	4.94***	5.17***	7.28***
	t-table (DF: 199; CI: 95%)	1.98	1.98	1.98	1.98	1.98
	p-value	0.089	0.001	<0.001	<0.001	<0.001

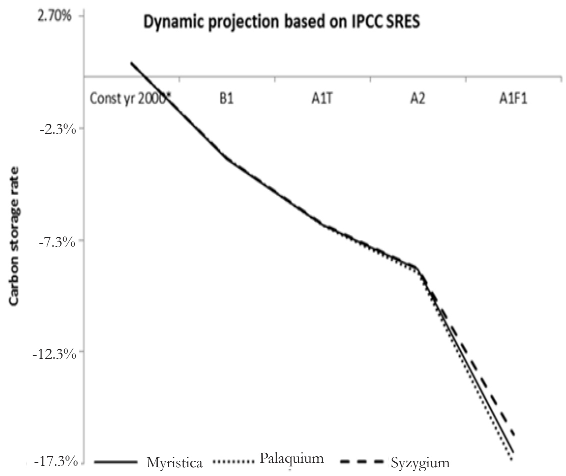


Figure 10. Trend of C storage deviation based on IPCC SRES climate scenarios

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REFERENCES

Achmad, E., Jaya, I. N. S., Saleh, M. B., & Kuncahyo, B. (2013). Biomass estimation using ALOS PALSAR for identification of lowland forest transition ecosystem in Jambi Province. J*urnal Manajemen Hutan Tropika*, *19*(2), 145–155. doi:10.7226/jtfm.19.2.145.

Allen, C. D., Macalady, A. K., Chenchouni, H., Bachelet, D., McDowell, N., Vennetier, M., … Cobb, N. (2010). A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. *Forest Ecology and Management*, *259*(4), 660–684. doi:j.foreco.2009.09.001.

Avery, T. E., & Harold, B. E. (2002). *Forest measurement*

(5th Edition). New York: McGraw-Hill.

Bennett, J. M., Cunningham, S. C., Connelly, C. A., Clarke, R. H., Thomson, J. R., & Nally, R. Mac. (2013). The interaction between a drying climate and land use affects forest structure and above-ground carbon storage. *Global Ecology and Biogeography, 22*(12), 1238–1247. doi:10.1111/geb.12083.

Bowman, D. M. J. S., Brienen, R. J. W., Gloor, E., Phillips, O. L., & Prior, L. D. (2013). Detecting trends in tree growth: not so simple. *Trends in Plant Science*, *18*(1), 11–17. doi:10.1016/j.tplants.2012.08.005.

Bugmann, H. (2001). A review of forest gap models. *Climatic Change*, *51*(3), 259–305. doi:10.1023/A:1012525626267.

Coops, N. C., & Waring, R. H. (2011). Estimating the vulnerability of fifteen tree species under changing climate in Northwest North America. *Ecological Modelling*, *222*(13), 2119–2129. doi:10.1016/j.ecolmodel.2011.03.033.

Dai, Z., Birdsey, R. A., Johnson, K. D., Dupuy, J. M., Hernandez-Stefanoni, J. L., & Richardson, K. (2014). Modeling carbon stocks in a secondary tropical dry forest in the Yucatan Peninsula, Mexico. *Water, Air, & Soil Pollution*, *225*(1925), 1–15. doi:10.1007/s11270-014-1925-x.

Dean, C., Roxburgh, S., & Mackey, B. (2003). Growth modelling of *Eucalyptus regnans* for carbon accounting at the landscape scale. In A. Amaro, D. Reed, & P. Soares (Eds.), *Modelling Forest Systems* (pp. 42–54). Cambridge, MA: CABI Publishing.

Dominati, E., Patterson, M., & Mackay, A. (2010). A framework for classifying and quantifying the natural capital and ecosystem services of soils. *Ecological Economics*, *69*(9), 1858–1868. doi:10.1016/j.ecolecon.2010.05.002.

Ford, A. (2010). *Modeling the environment. (*2nd Edition). Washington DC: Island Press.

Gardner, R. H. & Urban, D. L. (2003). Model validation and testing: past lessons, present concerns, future prospects. In C. D. Ganham, J. J. Cole, & W. Lauenroth (Eds.), *Models in Ecosystem Science*. Princeton, NJ: Princeton University Press.

Hairiah, K., & Rahayu, S. (2007). *Pengukuran karbon tersimpan di berbagai macam penggunaan lahan*. Bogor: ICRAF.

Heimann, M., & Reichstein, M. (2008). Terrestrial ecosystem carbon dynamics and climate feedbacks. *Nature*, *451*, 289–292. doi:10.1038/nature06591.

Hu, Y., Su, Z., Li, W., Li, J., & Ke, X. (2015). Influence of tree species composition and community structure on carbon density in a subtropical forest. *PLoS ONE*, *10*(8), 1–9. doi:10.1371/journal.pone.0136984.

Hunter, J. T. (2015). Changes in allometric attributes and biomass of forests and woodlands across an altitudinal and rainfall gradient : What are the implications of increasing seasonality due to anthropogenic climate change ? *International Journal of Ecology*, *2015*, 10 pages. Article ID 208975. doi:10.1155/2015/208975.

Intergovernmental Panel on Climate Change [IPCC]. (2000). IPCC Special report emissions scenarios: *Summary for policy makers Intergovernmental Panel on Climate Change*.

Intergovernmental Panel on Climate Change [IPCC]. (2007). Climate change 2007. *Synthesis report*. Retrieved from http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm on July 25, 2015.

Jaya, I. N. S. (2014). The interpolation method for estimating the aboveground biomass using terrestrial-based inventory. *Jurnal Manajemen Hutan Tropika*, *20*(2), 121–130. doi:10.7226/jtfm.20.2.121.

Jaya, I. N. S., Agustina, T. L., Saleh, M. B., Shimada, M., Kleinn, C., & Fehrmann, L. (2012). Above ground biomass estimation of dry land tropical forest using ALOS PALSAR in Central Kalimantan, Indonesia. In Proceeding of The 3rd DAAD *Workshop on: Forest in Climate Change Research and Policy: The Role of the Forest Management and Conservation in Complex International Setting* (pp. 1–19). Dubai (UAE). Retrieved from http://www.uni-geotingen.de/en/67094.html.

Laubhann, D., Sterba, H., Reinds, G. J., & Vries, W. De. (2009). The impact of atmospheric deposition and climate on forest growth in European monitoring plots: An individual tree growth model. *Forest Ecology and Management*, *258*(8), 1751–1761. doi:10.1016/j.foreco.2008.09.050.

Lemmens, R., Soerianegara, I., & Wong, W. C. (Eds.) (1995). *Plant Resources of South-East Asia 5(2), Timber tress: Minor commercial timbers*. Leiden: Backhuys Publishers.

Limbu, D., & Koirala, M. (2017). Aboveground and belowground biomass situation of milke-jaljale rangeland at different altitudinal gradient. *Our Nature*, *9*(1), 107–111. doi:10.3126/on.v9i1.5740.

Ma, J., Hu, Y., Bu, R., Chang, Y., Deng, H., & Qin, Q. (2014). Predicting impacts of climate change on the aboveground carbon sequestration rate of a temperate forest in northeastern china. *PLoS ONE*, *9*(4), 1–15. doi:10.1371/journal.pone.0096157.

Maulana, S. I., Wibisono, Y., & Utomo, S. (2016). Development of local allometric equation to estimate total aboveground biomass in Papua. *Indonesian Journal of Forestry Research*, *3*(2), 107–118. doi:10.20886/ijfr.2016.3.2.107-118.

Omeja, P. A., Obua, J., Rwetsiba, A., & Chapman, C. A. (2012). Biomass accumulation in tropical lands with different disturbance histories: Contrasts within one landscape and across regions. *Forest Ecology and Management*, *269*, 293–300. doi:10.1016/j.foreco.2011.12.044.

Oni, S. K., Dillon, P. J., Metcalfe, R. A., & Futter, M. N. (2012). Dynamic modelling of the impact of climate change and power flow management options using stella: Application to the Steephill Falls Reservoir, Ontario, Canada. *Canadian Water Resources Journal*, *37*(2), 125–148(24).doi:10.4296/cwrj3702831.

Pretzsch, H. (2009). *Forest dynamics, growth and yield: From measurement to model*. Berlin: Springer.

Ricker, M., Gutiérrez-García, G., & Daly, D. C. (2007). Modeling long-term tree growth curves in response to warming climate: Test cases from a subtropical mountain forest and a tropical rainforest in Mexico. *Canadian Journal of Forest Research*, *37*(5), 977–989. doi:10.1139/X06-304.

Santoso, B. (2008). *Kebijakan penerapan multisistem silvikultur pada hutan produksi Indonesi*a. Jakarta: Ditjen Bina Produksi Kehutanan, Departemen Kehutanan.

Sha, P., Gaodi, X., Changshun, Z., Chunlan, L., Shimei, L., Caixia, Z., & Long, C. (2015). Dynamic simulation of carbon sequestration by *Pinus sylvestris* var. *mongolica*. *Journal of Resources and Ecology*, *6*(1), 37–43. doi:10.5814/j.issn.1674-764x.2015.01.005.

Soerianegara, I., & Lemmens, R. (Eds.) (1993). *Plant Resources of South-East Asia 5(1), Timber trees: Major commercial timbers*. Wageningen: Pudoc & PROSEA.

Stinziano, J. R., & Way, D. A. (2014). Combined effects of rising [CO^2] and temperature on boreal forests: Growth, physiology and limitations. *Botany*, *92*(6), 425–436. doi:10.1139/cjb-2013-0314.

Subedi, N., & Sharma, M. (2013). Climate-diameter growth relationships of black spruce and jack pine trees in boreal Ontario, Canada. *Global Change Biology*, *19*(2), 505–516. doi:10.1111/gcb.12033.

Theurillat, J. P., & Guisan, A. (2001). Potential impact of climate change on vegetation in the European Alps: A review. *Climate Change*, *50*(1), 77-109. doi:10.1023/A:1010632015572.

Touchan, R., Shishov, V. V, Meko, D. M., Nouiri, I., & Grachev, A. (2012). Process based model sheds light on climate sensitivity of Mediterranean tree-ring width. *Biogeosciences*, *9*(3), 965–972. doi:10.5194/bg-9-965-2012.

Vanclay, J. K. (1994). *Modelling forest growth and yield: Application to mixed tropical forest*. Wallingford, UK: CAB International.

Wahjono, D., & Anwar. (2008). *Prospek penerapan multisistem silvikultur pada unit pengelolaan hutan produksi*. Bogor: Puslitbang Konservasi Alam, Departemen Kehutanan.

Wahyudi, & Anwar, M. (2013). Model pertumbuhan pohon-pohon di hutan alam paska tebangan studi kasus pada hutan alam produksi di Kabupaten Kapuas, Kalimantan Tengah. *Bionatura: Jurnal Ilmu-Ilmu Hayati dan Fisik*, *15*(3), 190–195.

Wang, J., Duan, B., & Zhang, Y. (2012). Effects of experimental warming on growth, biomass allocation, and needle chemistry of Abies faxoniana in even-aged monospecific stands. *Plant Ecology*, *213*(1), 47–55. doi:10.1007/s11258-011-0005-1.

Weiskittel, A. R., Hann, D. W., Kershaw, J. A., & Vanclay, J. K. (2011). *Forest growth and yield modeling*. West Sussex: Wiley-Blackwell.

DEMAND ANALYSIS OF INDONESIAN PULPWOOD USING TRANSCENDENTAL LOGARITHMIC MODEL: A STUDY OF THE WORLD AND SELECTED ASIAN MARKETS

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DEMAND ANALYSIS OF INDONESIAN PULPWOOD USING TRANSCENDENTAL LOGARITHMIC MODEL: A STUDY IN THE WORLD AND SELECTED ASIAN MARKETS. Indonesia's pulpwood export has shown an increasing trend since 1990s. Along with Brazil, Canada, USA and Chile, Indonesia became one of the top five pulpwood exporter countries in the world. Indonesia's pulpwood was traded mainly to some Asian countries. This paper examines Indonesian pulpwood export demand during the period 1994-2014 using a Transcendental Logarithmic (TL) model with Seemingly Unrelated Regression (SUR) estimation. Export data from the five top exporter countries in four different markets (China, Korea, Japan and the world) were analysed. The important findings are as follow: firstly, logarithmic income and second order logarithmic income significantly influence the Chinese and Korean markets. Secondly, in general, Indonesia's own-prices are elastic and have negative signs (-2.308, -1.06 and -2.04 in the Korean, Japanese and the world markets, respectively). Thirdly, due to its positive sign of cross-price elasticity and also positive signs of income elasticity (1.002, 1.722 and 0.625 in the Chinese, Korean and the world markets, respectively), Indonesian pulpwood could be categorized as a substitute and normal goods. Lastly, regarding to negative and elastic Indonesia's pulpwood own-prices, one possible policy that could be applied by the Government of Indonesia (GoI) is giving a subsidy to reduce pulpwood price by 10%. Subsidy could be implemented by reducing tax and retribution such as property tax (*Pajak Bumi dan Bangunan*) and local retribution (*Retribusi Daerah*). By doing so, it would give more benefit in the Korean market compared with other markets. Indonesia's share of demand would increase from 0.28 to 0.31 with high rate of return (>2). On the world markets, Indonesia's share of demand would increase from 0.08 to 0.1 with a return rate of 1.89. This study, therefore, suggests that a subsidy policy should be implemented for pulpwood industry in Indonesia.

Keywords: Pulpwood, export, demand share, transcendental logarithmic, policy

ANALISIS PERMINTAAN BUBUR KERTAS INDONESIA DENGAN MENGGUNAKAN MODEL TRANSCENDENTAL LOGARITHMICH: STUDI DI DUNIA DAN BEBERAPA PASAR ASIA. Ekspor bubur kertas Indonesia telah menunjukkan trend yang meningkat sejak era 1990an. Bersama Brazil, Canada, USA, dan Chili, Indonesia menjadi satu dari lima pengekspor bubur kertas terbesar di dunia. Bubur kertas Indonesia sebagian besar diekspor ke negara-negara Asia. Tulisan ini menganalisis permintaan ekspor bubur kertas Indonesia periode 1994-2014 menggunakan model Trancendental Logarithmic (TL) *dengan estimasi* Seemingly Unrelated Regression (SUR)*. Data ekspor dari lima negara pengekspor bubur kertas terbesar di empat pasar yang berbeda (Cina, Korea, Jepang, dan dunia) dianalisis. Hasil penelitian menunjukkan: pertama, logaritmik pendapatan dan second order logaritmik pendapatan yang berpengaruh signifikan di pasar Cina dan Korea; kedua, secara umum elastisitas harga bubur kertas Indonesia elastis dan negatif (-2,308, -1,06, dan -2,04 di pasar Korea, Jepang, dan dunia). Ketiga, sehubungan dengan nilai elastisitas yang positif pada harga bubur kertas negara lain dan juga positif pada elastisitas pendapatan (masing-masing 1,002, 1,722, dan 0,625 di pasar Cina, Korea, dan dunia), maka bubur kertas Indonesia dapat dikategorikan sebagai barang substitusi dan barang normal. Terakhir, terkait dengan nilai elastisitas harga bubur kertas Indonesia yang negatif dan elastis, satu*

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kebijakan yang dapat diterapkan oleh pemerintah Indonesia adalah pemberian subsidi untuk mengurangi harga bubur kertas Indonesia sebesar 10%. Subsidi dapat diimplementasikan dengan mengurangi pajak dan retribusi seperti Pajak Bumi dan Bangunan (PBB) dan retribusi daerah. Dengan melakukan hal ini maka akan memberikan manfaat lebih banyak di pasar Korea dibandingkan dengan pasar bubur kertas lainnya. Share permintaan di pasar Korea akan meningkat dari 0,28 menjadi 0,31 dengan nilai rate of return yang tinggi (>2). Pada pasar dunia, share permintaan bubur kertas Indonesia akan meningkat dari 0,08 menjadi 0,1 dengan nilai rate of return sebesar 1,89. Oleh sebab itu, studi ini menyarankan agar pemberian subsidi dapat dilakukan pada industri bubur kertas di Indonesia.

Kata kunci: Bubur kertas, ekspor, share permintaan, transcendental logarithmic, kebijakan

I. INTRODUCTION

Forestry sector, including forest industries, comprised around 2.5 % of Indonesian GDP during the period of 2012 – 2014 (Badan Pusat Statistik, 2016). Even though this sector's contribution to GDP is small compared to other sectors, forestry sector altogether with agriculture and fishery sectors has contributed by providing job opportunities. In addition, forestry sector is also considered as a booster for economic growth in Indonesia since forestry sector has contributed to the development of isolated areas (Nurrochmat et al., 2012).

Due to abundance of forest resources, Indonesia has become a major forest product exporter country in the world, specifically of pulpwood. In 2013, Indonesian pulpwood contributed 1.8 billion USD in total value added – second only to plywood (Kemenhut, 2014). This forest product has shown a dramatically increasing trend since 1990s. Pulpwood production reached more than 6 million tons in 2013. More than half of the total production (3.8 million tons) was traded mainly to some Asian countries such as China, Korea and Japan.

A demand for wood will continue to increase (FAO, 2009). In addition to this, Indonesia has been considered as a country that positively responds to wood global demand by expanding its pulp production and timber plantation industries (Obidzinski & Dermawan, 2012). Thus, it is important to analyse the demand structure of pulpwood for Indonesia. This paper investigates the demand function of Indonesian pulpwood on several markets, namely the Chinese, Korean, Japanese and the world markets. These three countries were chosen because approximately 81.5% of the total Indonesian pulpwood export (2.8 million tons) went to these countries in 2014. In addition, these Asian countries are the main partner countries for Indonesian forest products trade (Indonesia EU FLEGT Facility, 2016).

Three objectives are examined in this study. First, to learn the demand functions of Indonesian pulpwood on both selected Asian countries (China, Korea and Japan) and the world market. Next is to measure own-prices, cross-prices and incomes elasticity of the top five pulpwood exporter countries (Brazil, Canada, USA, Chile and Indonesia) including its effects on Indonesian pulpwood demand. The last is to examine the policy that can be applied to Indonesia's pulpwood industries.

Forest products demand function altogether with income and price elasticity have been researched by some scholars. There are various methods which can be used to analyse demand functions. They are different due to variables included in the models, data and econometric approaches that are applied. Turner and Buongiorno (2004) derived import demand for 10 (ten) forest product groups from generalized Cobb-Douglas production function and compared 5 (five) different methods both in static and dynamic models (Pooled OLS, First Differencing, Fixed effects, Random Effects, and the Arellano-Bond method). The explanatory variables consist of real import price and real GDP as proxy of income. The study used panel data from 64 countries from 1970 to 1987. The results found that the dynamic Arellano-Bond method gave the best result in measuring demand function.

Similarly the demand functions model was also studied by Simangunsong and Buongiorno in 2001. The data were gathered from 64 countries during the period of 1973-1997. In addition, five different econometric approaches namely Pooled OLS, Least Squares with Dummy Variables (LSDV), within-country and between-country regression, random effects and shrinkage estimation were compared, both statically and dynamically, to measure demand functions for nine groups of forest products. The result showed that the Least Squares with Dummy Variables (LSDV) was the most useful method to obtain demand functions. In addition, the study stated that static model could predict demand model better than dynamic model.

Demand for goods can also be measured based on international trade terms. Gravity model, for instance, is a model to analyse demand for export and import between two countries. This model suggests that distance is an important factor on determining the demand function. Distance variable is expected to have negative sign or relation on export and import demand. Tang, Song, Perez-Garcia, and Eastin (2015) used this model to measure Chinese wood pulp and recovered paper imports. Three econometric approaches namely Random effects, Fixed effects and Hausman-Taylor (HT) estimator were applied in the paper. Particularly for pulpwood, the study formulated the demand function which consists of GDP of both importer and exporter country as proxy of the economic development level, distance, exchange rate, pulpwood production per capita, dummy variables of APEC and WTO agreements. The study used data from 1995 to 2012. The finding suggested that HT estimator gave the best estimation and gravity model succeed in explaining the Chinese pulpwood and recovered paper import.

Another approach to measure demand structure is Transcendental Logarithmic (TL) model which was first introduced by Christensen, Jorgenson, and Lau (1975). Then, the model was developed by Swamy and Binswanger (1983). The study compared three demand functions namely Normalized Quadratic demand, Generalized Leontief demand and Transcendental Logarithmic demand (TL). The result suggested that compared to the other demand functions, TL is better in terms of symmetry and homogeneity restrictions. Wilson (1994) added TL model is more general than the Almost Ideal Demand System (AIDS) model. Moreover, this model has flexibility in function form and satisfies all restrictions of demand function: homogeneity, symmetry and adding-up constraint.

Even though there are various models that can be used to study demand functions, most studies show that the sign of own-price and income elasticity are consistent. Own-price is negatively correlated with pulpwood demand, while income is positively correlated with the quantity of pulpwood demanded. However, the magnitude of own-price and income elasticity could be different. Some scholars, for instance, Turner and Buongiorno (2004) and Chou and Buongiorno (1984) found that own-price was inelastic (-0.48 and -0.88, respectively), whereas Detomasi (1969) found pulp/waste paper's own-price was elastic (-12.55). Different results were also obtained for income elasticity. Turner and Buongiorno (2004) found the income elasticity was elastic (2.7), while Kreinin (1973) found income was inelastic (0.75).

This paper is clearly different with the previous studies in terms of the methodology. Most of them use Ordinary Least Square (OLS), fixed effects, random effects and other econometric approaches both in static and dynamic terms. Whereas, this study uses Transcendental Logarithmic (TL) model with Seemingly Unrelated Regression (SUR) estimation with more focus on demand for Indonesian pulpwood in the Chinese, Korean, Japanese and the world markets. Other than that, this model is a static model. Therefore, the result is expected to be more precise than dynamic models, especially in estimating the demand function.

II. MATERIAL AND METHOD

A. Materials

This study uses secondary data from United Nation Commodity Trade Statistics Database (International Trade Statistics, 2015). The data consists of volume (in tons) and value (in US$) of pulpwood exported from the top five producer countries namely Brazil, Canada, USA, Chile and Indonesia. The prices are approximated by dividing the total value of pulpwood export with the total volume of pulpwood exported. The data series used is on an annual basis from 1994 to 2014. In addition, the world and some Asian countries (China, Korea and Japan) are chosen as pulpwood markets. Pulpwood that is used in this study is classified in Harmonized System (HS) 4703 (4 digits) and is defined as chemical wood pulp, soda or sulphate and not dissolving grade.

B. Methods

Transcendental Logarithmic (TL) function was introduced by Christensen et al. (1975) and then followed by Swamy and Binswanger (1983) is applied to estimate Indonesian chemical pulpwood demand on the Chinese, Korean, Japanese and the world markets.In general, Transcendental Logarithmic (TL) model can be seen as below.

$$S_i = \alpha_i + \beta_{i1}\log(M) + \beta_{i2}(\log(M))^2 + \sum_{j=1}^{N} \gamma_{ij}\log(P_j) \quad (1)$$

where:

S_i = share of an exporter country i in a particular market,

$log\ (M)$ = logarithm of real expenditure/income,

$(\log\ (M))^2$ = second order logarithm of real expenditure/income,

$\log(P_j)$ = logarithmic price of exporter country j,

j = 1, 2, …, N (the number of exporter countries),

i = 1, 2, …, N-1.

Since this study uses export data from 5 top chemical pulpwood exporter countries (Brazil, Canada, USA, Chile and Indonesia) in 4 different markets (the world, China, Korea and Japan) then the model was reconstructed as follows:

$$S_{im} = \alpha_{im} + \beta_{1im} LogM_m + \beta_{2im}(Log(M))^2{}_m + \sum_{j=1}^{N} \Upsilon_{ijm}\log(P_{jm}) \quad (2)$$

where:

S_{im} = share of an exporter country i in a particular pulpwood country market m,

m = 1, 2, 3, 4 refers to Chinese, Korean, Japanese and the world markets,

j = Number of exporter countries (N).

j = 1, 2, 3, 4, 5 refer to Brazil, Canada, USA, Chile and Indonesia respectively,

i = 1, 2, …, N-1.

This study imposes demand restrictions on the model as follows:

Homogeneous of degree 0 $\Sigma_j \Upsilon_{ijm} = 0 \quad \forall\, im$

Symmetry $\Upsilon_{ij} = \Upsilon_{ji} \quad \forall\, im$

Along with the model, in order to avoid singularity, one equation should be omitted from the system. In this study, there are five equations of exporters' share demand in each market. Thus, one of them should be deleted. The dropped equation should be the least share from the exporter countries. However, on the Japanese and the world markets, the least share of pulpwood exporter is Indonesia, as a consequence the deleted equation is the second least exporter.

C. Analysis

Four steps were carried out in order to answer the objectives of this study. Firstly, the cross-equation error correlation was tested. Followed by estimating Indonesia's demand function using SUR estimation. Next price (own-and cross-price) elasticity and income elasticity was calculated using Eq. 3 and Eq. 4. The last was analysing the policy that could be implemented by the Indonesian government based on the yielded results. The STATA program was used to measure the first two aforementioned steps. The last two steps were calculated by using Excel Program through formula from Eq. 3 to Eq. 10.

1. Testing for cross-equation error correlation

Transcendental Logarithmic (TL) demand function using SUR estimation which was used in this study consisted of identical variables in all system of equations (Eq. 2). For that reason, Breusch and Pagan's test (Breusch and Pagan, 1980) was applied on STATA program to examine the correlation matrix of errors across the equations.

This error correlation can be captured by examining the covariance value. The hypothesis can be seen as follows:

H_0 : σ12= σ13= … = σ45 = 0; where σ12= σ13= … = σ45 are defined as covariance of errors across different equations,
H_1 : at least one covariance is nonzero,
H_0 : can be rejected if any of covariance is nonzero.

2. Price and income elasticity

This study used Swamy and Binswanger's model to measure price and income elasticity. Swamy and Binswanger (1983) formulated price and income elasticity as follows:

Price Elasticity:

$$E_{ij} = \frac{\Upsilon_{ij}}{\hat{S}_i} + \hat{S}_j - \delta_{ij} \qquad i \neq j \qquad (3)$$

where:
Υ_{ij} = coefficient of P_{ij} ,
i = exporter country *i*,
j = other exporter country *j*,
$\hat{S}_i$ = mean value of demand share exporter country *i*,
$\hat{S}_j$ = mean value of demand share exporter country *j*,
δ_{ij} = Kronecker delta, $\delta_{ij} = 1$ if i=j, and $\delta_{ij} = 0$ otherwise.

Income Elasticity:

$$E_{im} = \frac{\beta_{i1} + 2\beta i2 \log(M)}{\hat{S}_i} + 1 \qquad i < n \qquad (4)$$

where:
β_{i1} = coefficient of logarithmic real income exporter country *i*,
β_{i2} = coefficient of second order logarithmic real income exporter country *i*,
i = exporter country *i*,
$\hat{S}_i$ = mean value of demand share country *i*,
$log\ (M)$ = logarithm of real expenditure/ income on pulpwood.

III. RESULT AND DISCUSSION

A. Breusch-Pagan Test of Error Correlation

Table 1 shows the result of Breusch-Pagan test for pulpwood demand from the top five exporter countries on the Chinese, Korean, Japanese and the world markets. The correlation of the residuals among demand shares are nonzero, thus this study rejects H_o (σs1s2= σs2s3= … = σs4s5 = 0). It means there are correlations among the residuals.

Table 2 shows Chi-square (Chi^2) values and probability values of Breusch-Pagan test of independencies. All probability values are considered small for all markets: 0.0045 (Chinese market), 0.0000 (Korean market), 0.0613 (Japanese market) and 0.0006 (the world market). The results indicate that the equations in each market is jointly either positively or negatively significant at level 1% for Chinese, Korean and the world markets, and significant at 10% for Japanese pulpwood market. This study, therefore, can be continued by regressing Transcendental Logarithmic (TL) demand model with Seemingly Unrelated Regression (SUR) estimation.

B. Seemingly Unrelated Regression (SUR) Estimation

Table 3 represents SUR estimation of pulpwood demand for the top 5 exporter pulpwood countries in four different markets. Based on the list at row 8 on the Chinese market there are four significant independent variables, namely: logarithmic income (β_{i1}), second order

Table 1. Correlation matrix of residuals for the top five exporter countries on four different markets

Breusch-Pagan test of error correlation

Export to China	σ_{s1}	σ_{s2}	σ_{s4}	σ_{s5}	Export to Korea	σ_{s2}	σ_{s3}	σ_{s4}	σ_{s5}
σ_{s1}	1.0000				σ_{s2}	1.0000			
σ_{s2}	0.0522	1.0000			σ_{s3}	0.4094	1.0000		
σ_{s4}	-0.0879	-0.0347	1.0000		σ_{s4}	-0.7509	-0.4715	1.0000	
σ_{s5}	-0.2916	-0.7043	-0.5506	1.0000	σ_{s5}	-0.2058	-0.6598	-0.0631	1.0000

Export to Japan	σ_{s1}	σ_{s2}	σ_{s3}	σ_{s5}	Export to the world	σ_{s1}	σ_{s2}	σ_{s3}	σ_{s5}
σ_{s1}	1.0000				σ_{s1}	1.0000			
σ_{s2}	-0.0811	1.0000			σ_{s2}	-0.7932	1.0000		
σ_{s3}	-0.1924	-0.5286	1.0000		σ_{s3}	0.1823	-0.5776	1.0000	
σ_{s5}	0.1559	-0.3843	0.2789	1.0000	σ_{s5}	-0.0101	0.0219	-0.3582	1.0000

Table 2. Chi-square (Chi^2) value with 6 degree of freedom for all markets

No.	Test of independence	Chi^2 (6)	Probability	Remarks
1.	Export to Chinese market	18.814	0.0045	There are correlation among errors
2.	Export to Korean market	30.142	0.0000	There are correlation among errors
3.	Export to Japanese market	12.028	0.0613	There are correlation among errors
4.	Export to the world	23.622	0.0006	There are correlation among errors

logarithmic income (β_{i2}), Canadian pulpwood price (ϒ2) and Indonesian pulpwood own-price (ϒ5). Similar patterns are also shown in the Korean market (row 16). Logarithmic income (βi1), second order logarithmic income (βi2) and Indonesian pulpwood own-price (ϒ5) significantly influence Indonesia's pulpwood demand too. Yet, another country's price is influenced by USA's pulpwood price (ϒ3) instead of Canadian pulpwood price (ϒ2). On row 32, the list point out that Indonesia's pulpwood own-price (ϒ5) and USA's pulpwood price (ϒ3) influence Indonesia's pulpwood demand significantly on the world market as well. Particularly, on the Japanese pulpwood market (row 24) there is no significant independent variable.

Looking at in more details about Indonesian share demand on the Chinese market (row 7), the total expenditure or income denoted by Log (M) has positive sign on the coefficient variable (β_{i1}). It means that the rise of expenditure will also increase the demand share of Indonesian pulpwood. Second order logarithmic income $(Log (M))^2$ on demand share of Indonesian pulpwood has negative sign on coefficient parameter β_{i2}, which means that the increase of Indonesian pulpwood demand due to an increasing expenditure will hold diminishing pattern. Furthermore, the coefficient of Indonesia's own-price (ϒ5) to the Chinese market is positive and explains that an increase of Indonesian pulpwood price will escalate the pulpwood export to China. On the other hand, other country's pulpwood price (Canada's (Υ_2) price) will negatively affect the share of Indonesian pulpwood demand and it is shown by the negative sign of the Canadian pulpwood

Table 3. Seemingly Unrelated Regression (SUR) estimation

Equations	Dependent Variables	Independent Variables								Remarks
		αi	βi1	βi2	ϒ1	ϒ2	ϒ3	ϒ4	ϒ5	
Chinese market										
1. Brazil	S1	-2.796	0.216	-0.004	0.024	0.084	0.062	-0.117	-0.053	(3) USA share omitted
		(4.363)	(0.409)	(0.009)	(0.081)	(0.076)	(0.047)	(0.074)	(0.077)	
2. Canada	S2	35.191	-3.217	0.074	0.084	-0.032	-0.031	0.267	-0.288	
		(5.904)***	(0.553)***	(0.012)***	(0.076)	(0.142)	(0.066)	(0.111)**	(0.099)***	
4. Chile	S4	-2.614	0.246	-0.006	-0.117	0.267	-0.004	-0.155	0.009	
		(6.553)	(0.614)	(0.014)	(0.074)	(0.111)**	(0.061)	(0.124)	(0.099)	
5. Indonesia	S5	-35.891	3.426	-0.081	-0.053	-0.288	-0.021	0.009	0.3545851	
(8)		(8.580)***	(0.804)***	(0.018)***	(0.077)	(0.077)***	(0.070)	(0.099)	(0.154)**	
Korean market										
2. Canada	S2	-65.700	6.690	-0.169	0.098	-0.288	-0.103	0.266	0.027	(1) Brazil share omitted
		(86.598)	(8.452)	(0.206)	(0.087)	(0.195)	(0.126)	(0.152)*	(0.096)	
3. USA	S3	-167.879	16.575	-0.408	0.116	-0.103	-0.442	0.031	0.398	
		(68.033)**	(6.645)**	(0.162)**	(0.079)	(0.126)	(0.157)***	(0.142)	(0.088)***	
4. Chile	S4	19.684	-2.089	0.055	-0.177	0.266	0.031	0.008	-0.128	
		(76.701)	(7.488)	(0.182)	(0.088)	(0.152)*	(0.142)	(0.194)	(0.099)	
5. Indonesia	S5	168.950	-16.615	0.409	0.038	0.027	0.398	-0.128	-0.335	
(16)		(64.118)***	(6.254)***	(0.152)***	(0.075)	(0.096)	(0.088)***	(0.099)	(0.095)***	
Japanese market										
1. Brazil	S1	-18.318	1.778	-0.043	0.160	-0.075	0.086	-0.130	-0.040	(4) Chile share omitted
		(12.374)	(1.182)	(0.028)	(0.052)***	(0.045)*	(0.046)*	(0.051)**	(0.030)	
2. Canada	S2	-30.041	2.727	-0.061	-0.075	0.038	0.125	-0.088	0.001	
		(49.555)	(4.742)	(0.113)	(0.045)*	(0.185)	(0.104)	(0.114)	(0.080)	
3. USA	S3	57.595	-5.365	0.125	0.086	0.125	-0.203	0.022	-0.031	
		(28.663)**	(2.742)**	(0.065)*	(0.046)*	(0.104)	(0.099)**	(0.085)	(0.052)	
5. Indonesia	S5	0.877	0.000	-0.002	-0.040	0.001	-0.031	0.078	-0.007	
(24)		(23.871)	(2.285)	(0.054)	(0.030)	(0.080)	(0.052)	(0.057)	(0.048)	
the world market										
1. Brazil	S1	16.056	-1.514	0.036	-0.145	0.146	0.109	-0.122	0.012	(4) Chile share omitted
		(30.820)	(2.650)	(0.056)	(0.037)***	(0.052)***	(0.031)***	(0.038)***	(0.021)	
2. Canada	S2	-51.676	4.740	-0.107	0.146	-0.153	-0.203	0.187	0.022	
		(48.711)	(4.189)	(0.090)	(0.052)***	(0.103)	(0.057)***	(0.060)***	(0.033)	
3. USA	S3	5.236	-0.464	0.011	0.109	-0.203	0.074	-0.045	0.065	
		(39.655)	(3.410)	(0.073)	(0.031)***	(0.057)***	(0.050)	(0.044)	(0.025)**	
5. Indonesia	S5	33.665	-2.919	0.063	0.012	0.022	0.065	-0.023	-0.075	
(32)		(23.497)	(2.019)	(0.043)	(0.021)	(0.033)	(0.025)**	(0.032)	(0.022)***	

Note: The numbers in parentheses are standard errors, (***) significant at 1%, (**) significant at 5%, (*) significant at 10%

price. It suggests that an increase of Canadian pulpwood price will decrease the demand share of Indonesian pulpwood.

On contrary, the opposite result is obtained for demand of Indonesian pulpwood on the Korean market (row 15). Pulpwood demand in this country has negative sign of coefficient parameter β_{i1} in respond to income variable (Log (M)). An increase of expenditure will decrease the demand share of Indonesia's pulpwood export. Furthermore, the second order logarithmic expenditure $(\text{Log (M)})^2$ shows positive sign instead of negative sign of coefficient parameter β_{i2}.

In relation to Indonesia's own-price (ϒ5), the coefficient of this variable is negative on the Korean market. It means that an increase of its own-price will decrease the demand share of Indonesian pulpwood export to Korea. Meanwhile, share of Indonesian pulpwood demand is positively influenced by USA's pulpwood price (ϒ3). The increase of USA's pulpwood prices will positively correspond to an increase of Indonesian pulpwood export.

Similar results related to the sign of its own-price and other country variables are shown in the world market on row 31. The coefficient of Indonesia's own-price (ϒ5) is negative which means that an increase of its own-price will decrease the demand share of Indonesian

Table 4. Own- and cross-price elasticity of pulpwood demand

No.	Markets	Cross-Price Elasticity			Own-price Elasticity
1.	China	Brazil	Canada	Chile	Indonesia
	Brazil	-0.687	0.902	-0.640	-0.144
	Canada	0.409	-0.783	1.011	-0.680
	Chile	-0.543	1.893	-1.746	0.277
	Indonesia	**-0.091**	**-0.951 (***)**	**0.207**	**0.789**
2.	Korea	Canada	USA	Chile	Indonesia
	Canada	-1.659	-0.118	1.048	0.310
	USA	-0.158	-2.743	0.301	1.990
	Chile	1.929	0.416	-0.789	-0.565
	Indonesia	**0.423**	**2.038 (***)**	**-0.419**	**-2.308**
3.	Japan	Brazil	Canada	USA	Indonesia
	Brazil	0.347	-0.128	0.954	-0.246
	Canada	-0.038	-0.471	0.583	0.063
	USA	0.417	0.858	-1.372	-0.040
	Indonesia	**-0.530**	**0.454**	**-0.197**	**-1.060**
4.	the world	Brazil	Canada	USA	Indonesia
	Brazil	-1.656	1.234	0.867	0.134
	Canada	0.543	-0.988	-0.267	0.124
	USA	0.621	-0.433	-0.452	0.332
	Indonesia	**0.347**	**0.729**	**1.194 (**)**	**-2.048**

pulpwood export to the world market. The share of Indonesian pulpwood export is also positively affected by USA's pulpwood price (Υ_3). Then, the increase of USA's pulpwood prices will correspond to an increase of Indonesian pulpwood export to the world market.

C. Price and Income Elasticity

1. Own- and cross-price elasticity

Table 4 shows the own- and cross-price elasticity of pulpwood demand for the top five exporter countries. Own-price elasticity indicates that the change in pulpwood demand correspond to the change in the price of the same goods. Looking in more detail, the own-prices show negative signs for Indonesian pulpwood on the Korean, Japanese and the world markets. The value of own-price elasticity is -2.308, -1.06 and -2.04 on the Korean, Japanese and the world markets respectively, which are considered as elastic. It means that an increase in Indonesian pulpwood price will bring a significant negative effect on pulpwood demand by those markets. This is supported by Detomasi (1969) which resulted in -12.55 of own-price, while Turner and Buongiorno (2004) suggested that own-price of pulpwood is considered as inelastic and accounted for -0.84 of own-price elasticity. Thus, this study conform the demand theory that the higher the price of pulpwood the smaller quantity will be demanded. It has happened on the Korean, Japanese and the world market.

Interestingly, different result is shown for demand of Indonesian pulpwood on the Chinese market. The own-price is inelastic (< 1), and it has a positive sign which means that Indonesian pulpwood price will not give a significant effect on the Chinese pulpwood demand. In addition, if the price of Indonesian pulpwood goes up, the demand of Indonesian pulpwood will keep increasing. One of the possible explanations of why China keeps continuing to import Indonesian pulpwood even though the price rise is due to its high economic growth (Tang et al., 2015). Another explanation is that Indonesian pulpwood production keeps growing and able to meet

Table 5. Income elasticity of pulpwood demand among top five pulpwood exporter countries

No.	Markets	Exporter countries	Income elasticity
1.	China		
		Brazil	1.413
		Canada	0.733
		Chile	1.072
		Indonesia	**1.002**
2.	Korea		
		Canada	0.169
		USA	0.226
		Chile	2.085
		Indonesia	**1.722**
3.	Japan		
		Brazil	1.033
		Canada	1.481
		USA	0.460
		Indonesia	**-0.308**
4.	Global world		
		Brazil	1.655
		Canada	0.581
		USA	1.119
		Indonesia	**0.622**

China's demand.

The cross-price elasticity in four markets varies within the top five pulpwood exporter countries. Positive cross-price elasticity indicates that pulpwood is substitute goods, while the negative elasticity shows that the pulpwood is complementary goods. The results show that both substitute and complementary goods exist in pulpwood trade in all markets. However, according to the result, pulpwood can be considered as a substitute goods. This is clearly shown in Table 5 that out of three significant cross-prices elasticity, two (2) of them (USA's pulpwood prices) have positive sign (2.038 and 1.194 on the Korean and the world markets, respectively). It means that Indonesian pulpwood product can be substituted by USA's pulpwood products.

2. Income elasticity

Table 5 represents income elasticity of pulpwood demand from the top five exporter countries. Changes of world income induce a positive influence on the share demand of Indonesian pulpwood to the Chinese, Korean and the world markets. Income elasticity is elastic in the Chinese and Korean markets (1.002 and 1.722, respectively). These results are supported by Turner and Buongiorno's study in 2004 which mentioned that income is elastic for pulpwood product (2.72). Meanwhile, income is considered as an inelastic elasticity in the world market (0.625).

As the economic theory mention, a positive sign of income elasticity indicates normal goods, while the negative elasticity is categorized as inferior goods. Based on the results above, Indonesian pulpwood can be considered as normal goods. This is shown in Table 5 that out of four income elasticity values, three (3) of them have positive signs. It means that the higher the expenditure on pulpwood, the more Indonesian pulpwood is demanded. However, particularly on the Japanese market, income has negative effect on demand of Indonesian pulpwood export.

An elastic income on demand of Indonesian pulpwood brings advantage for Indonesian pulpwood exporters to the Chinese and Korean markets. For instance, if Chinese and Korean consumers have higher income in the future, both countries will spend larger portion of their income for Indonesian pulpwood. On the other hand, if their incomes decrease, these two countries will import the pulpwood from Canada. Then, Indonesian pulpwood demand will decrease.

D. Policy Analysis

This study finds that Indonesia's pulpwood own-prices are mostly negative and elastic. This negative and elastic own-price indicates that a slightly reduced Indonesian pulpwood price would bring a huge increase in quantity demand of Indonesian pulpwood. Thus, one possible policy that could be implemented by the Government of Indonesia (GoI) is imposing a subsidy policy. The author conducted a scenario in which the GoI gives subsidy to pulpwood companies in order to reduce pulpwood price by 10%. Similar policy had been implemented by the GoI when the GoI imposed a plantation subsidy to HTI holders from the Reforestation Fund (*Dana Reboisasi*) between 1993 and 1998 (Barr, 2001). A -10% subsidy scenario is chosen since it would give a higher rate of return compared to a -20% subsidy.

Generally, forest industry including pulpwood industry has linkage or connection with the forest plantation industry which is called forward linkage (Nurrochmat et al., 2016). Giving subsidy to forest plantation industry would give benefit for the pulpwood industry as well, for instance the lower raw material (wood) cost for pulpwood industry. Thus, it would finally cause in lower price of pulpwood produced. In addition, Nurrochmat et al. (2016) mentioned that giving subsidy to local producers is one of several ways to promote forest products export. In this paper, giving subsidy could be implemented by reducing tax and retribution such as property tax (*Pajak Bumi dan Bangunan*) and local retribution (*Retribusi Daerah*) that still are considered high.

Suppose the current Indonesian pulpwood sales (M) is price (P) x quantity (Q). By doing so, it will lead to the decrease of the initial price (P) to the new pulpwood price (P'). At the new price, 10% cheaper than the Indonesian pulpwood price in 2014, the quantity of Indonesian pulpwood demand is expected to increase in all markets. The increase in quantity (ΔQ) can be calculated by using the formula:

$$\Delta Q(in\,tons) = 10\% \times \varepsilon \times Q \quad (5)$$

Then, the total Indonesian pulpwood demand becomes:

$$Q' = \Delta Q + Q \quad (6)$$

Thus, the total new sales (M') can be measured as follow:

$$M' = P' \times Q' \quad (7)$$

In regard to examine whether giving subsidy of 10% gives benefit for Indonesia or not, thus the gain yielded, cost needed, and the rate of return resulted due to this policy should be compared. Suppose world sales do not change, the total sales (M) of Indonesian pulpwood would increase by ε. The gain yielded due to the policy can be calculated by the gain equation below:

$$Gain = 10\% \times \varepsilon \times M \quad (8)$$

Then, the cost that the GoI should spend can be estimated by using formula:

$$Cost = 10\% \times Q' \times P' \quad (9)$$

Therefore, rate of return of this policy can be measured by the formula below:

$$Rate\,of\,Return = \frac{Gain}{Cost} \quad (10)$$

Table 6 shows the projection of this scenario. Based on the assumption, the quantity of Indonesian pulpwood demand would increase in the Korean, Japanese and the world markets. In line with these increments, Indonesia's share of demand would also increase from 0.28 to 0.31 and from 0.08 to 0.1 in the Korean and the world markets, respectively. In contrast on the Japanese market, the share of pulpwood demand from Indonesia would eventually decrease from 0.09 to 0.08. While in the Chinese

Table 6. Subsidy scenario: GoI gives subsidy that reduces Indonesian pulpwood price by 10%

No.	Markets	Items	Initial values	Projection of subsidy scenario
1.	China	Total sales (USD)	1,087,434,050	901,513,402
		Quantity (tons)	2,202,894	2,029,179
		GoI's cost (USD)	-	90,151,340
		Gain (USD)	-	85,752,492
		Rate of return	-	0.95
		Share of demand	0.17	0.14
2.	Korea	Total sales (USD)	238,704,096	264,411,639
		Quantity (tons)	493,626	607,542
		GoI's cost (USD)	-	26,441,164
		Gain (USD)	-	55,086,614
		Rate of return	-	2.08
		Share of demand	0.28	0.31
3.	Japan	Total sales (USD)	76,857,082	76,502,115
		Quantity (tons)	154,582	170,965
		GoI's cost (USD)	-	7,650,211
		Gain (USD)	-	8,145,268
		Rate of return	-	1.06
		Share of demand	0.09	0.08
4.	World	Total sales (USD)	1,718,324,937	1,863,230,100
		Quantity (tons)	3,497,111	4,213,356
		GoI's cost (USD)	-	186,323,010
		Gain (USD)	-	351,930,730
		Rate of return	-	1.89
		Share of demand	0.08	0.10

market, the pulpwood quantity demand would decrease. Furthermore, the share of Indonesian pulpwood demand would also be decreasing from 0.17 to 0.14.

In terms of implementing the subsidy policy, GoI would spend 90.15 million USD, 26.44 million USD, 7.65 million USD, and 186.32 million USD in the Chinese, Korean, Japanese, and the world markets, respectively. Indonesian pulpwood industry will gain 85.75 million USD with the rate of return of 0.95 in the Chinese market, 55.08 million USD with the rate of return of 2.08 in the Korean's market, 8.14 million USD with the rate of return of 1.06 in the Japanese market, and 351.93 million USD with the rate of return of 1.89 in the world market. It means that giving a subsidy would give more benefit to the Indonesian pulpwood industry in the Korean's market rather than on the other markets. Regarding the market share, Indonesia's share of demand would increase from 0.08 to 0.1 in the world market. This study, therefore, suggests that a subsidy policy should be implemented on the Indonesian pulpwood industry.

Studying the demand function by using Transcendental Logarithmic (TL) model indeed gives flexibility in function form and satisfies all restrictions of demand function. This model, however, still has limitations. Since it is a static model, thus it cannot be used to forecast a demand function in a particular time because the forecast result would be the same for each year. In addition, it cannot give trends of Indonesian pulpwood export demand during the study period. Thus, policy makers still need to consider the dynamic model in order to capture the trends and to construct various projections.

IV. CONCLUSION

This paper finds that the demand of Indonesian pulpwood is significantly influenced by both logarithmic income (Log (M)) and second order logarithmic income $(\text{Log }(M))^2$ in the Chinese and Korean markets. Canada's pulpwood price (ϒ2) significantly affects Indonesian pulpwood demand in the Chinese market, while USA's pulpwood price (ϒ3) affects Indonesian pulpwood demand in the Koreans and the world markets. Indonesia's own-price (ϒ5) significantly influences its own demand in all markets, except for the Japanese market.

Regarding to elasticity, this paper highlights Indonesia's own-prices in almost all of the markets are elastic and have negative signs (-2.308, -1.06 and -2.04 in the Korean, Japanese and the world markets, respectively), whereas, Indonesia's own-price is inelastic and has positive sign only in the Chinese market (0.789). There are two possible explanations for this situation. Firstly, China keeps continuing the high economic growth. Another explanation is that Indonesian pulpwood production could meet China's demand.

Concerning the cross-price elasticity, this study finds that out of 3 (three) significant cross-prices elasticity, two (2) of them (USA's pulpwood prices) have positive sign (2.038 and 1.194 in the Korean and the world markets, respectively). The positive sign of cross-price elasticity explains that Indonesian pulpwood product can be substituted by USA's pulpwood.

In term of income elasticity, Indonesian pulpwood can be categorized as normal goods due to its positive sign in majority markets (1.002, 1.722 and 0.625 in the Chinese, Korean and the world markets, respectively). It means that increase of income leads to increase of pulpwood demand. On contrary, income elasticity has negative sign in the Japanese market with the value less than one (-0.308). It means that income is not a significant factor for the Japanese pulpwood demand.

Based on the policy analysis projection, the scenario assumes that GoI imposes subsidy in order to reduce Indonesia's pulpwood price by 10%. This study points out that this scenario would give more benefit in the Korean market compared with other markets. It has high rate of return (>2). Overall, in terms of market share, Indonesia's share of demand would increase from 0.08 to 0.1 with rate of return 1.89 in the world market. This study, therefore, suggests that a subsidy policy should be implemented for pulpwood industry in Indonesia.

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REFERENCES

Badan Pusat Statistik. (2016). *percentage distribution of gross domestic product at current market prices by industrial origin, 2000-2014*. Retrieved from http://www.bps.go.id/linkTabelStatis/view/id/1207 on 3 January 2016.

Barr, C. (2001). *Banking on sustainability* (1st ed.). Washington, DC: WWF Macroeconomics Program Office.

Breusch, T. S., & Pagan, A. R. (1980). The lagrange multiplier test and its applications to model specification in econometrics. *The Review of Economic Studies*, *47*(1), 239–253. doi:10.2307/2297111

Chou, J. J., & Buongiorno, J. (1984). Demand functions for United States forest product exports to the European economic community. *Wood and Fiber Science*, *16*(2), 158–168.

Christensen, L. R., Jorgenson, D. W., & Lau, L. J. (1975). Transcendental logarithmic utility functions. *The American Economic Review*, *65*(3), 367–383.

Detomasi, D. D. (1969). The elasticity of demand for Canadian exports to the United States. *The Canadian Journal of Economics*, *2*(3), 416–426.

EU FLEGT Facility. (2016). Euflegt.efi.int. Retrieved from http://www.euflegt.efi.int/indonesia on 1 November 2016.

FAO. (2009). *State of the world's forests 2009* (1st ed.). Rome: FAO.

International Trade Statistics. (2015). Comtrade.un.org. Retrieved from https://comtrade.un.org/data/ on 7 November 2015.

Kementerian Kehutanan. (2014). *Statistik kehutanan Indonesia tahun 2013*. Jakarta: Biro Perencanaan, Kementerian Kehutanan.

Kreinin, M. E. (1973). Disaggregated import demand functions : Further results. *Southern Economic Journal*, *40*(1), 19–25.

Nurrochmat, D. R., Hasan, M. F., Suharjito, D., Budiaman, A., Hadianto, A., Ekayani, M., Ryandi, E.D. (2012). In: D.R. Nurrochmat & M.F. Hasan (Eds.). *Ekonomi politik kehutanan. Mengurai mitos dan fakta pengelolaan hutan*. (2nd edition, revised version). INDEF: Jakarta.

Nurrochmat, D.R., Darusman, D.R., Ekayani, M. (2016). *Kebijakan pembangunan kehutanan dan lingkungan: Teori dan implementasi*. Bogor: IPB Press.

Obidzinski, K. & Dermawan, A. (2012). Pulp industry and environment in Indonesia: is there sustainable future?. *Regional Environmental Change*, *12*(4), 961-966. doi:10.1007/s10113-012-0353-y.

Simangunsong, B. & Buongiorno, J. (2001). International demand equations for forest products: A comparison of methods. *Scandinavian Journal of Forest Research*, *16*(2), 155-172. doi:10.1080/028275801300088242.

Swamy, G. & Binswanger, H. (1983). Flexible consumer demand systems and linear estimation: Food in India. *American Journal of Agricultural Economics*, *65*(4), 675-684. doi:10.2307/1240455.

Tang, S., Song, W., Perez-Garcia, J., & Eastin, I. L. (2015). An empirical analysis of China's wood pulp and recovered paper imports using an augmented gravity model approach. *Forest Products Journal*, *65*(7-8), 381–386. doi:10.13073/fpj-d-14-00080.

Turner, J. A., & Buongiorno, J. (2004). Estimating price and income elasticities of demand for imports of forest products from panel data. *Scandinavian Journal of Forest Research*, *19*(4), 358–373. doi:10.1080/02827580410030127.

Wilson, W. W. (1994). Demand for wheat classes by Pacific Rim countries. *Journal of Agricultural and Resource Economics*, *19*(1), 197–209.

STAKEHOLDERS' PERCEPTION ON MANAGEMENT OF UPSTREAM CILIWUNG WATERSHED: IMPLICATIONS FOR FOREST LANDSCAPE PLANNING

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STAKEHOLDERS' PERCEPTION ON MANAGEMENT OF UPSTREAM CILIWUNG WATERSHED: IMPLICATIONS FOR FOREST LANDSCAPE PLANNING. Forests play a vital role for the livelihoods of rural and urban communities. Addressing perception of forest users regarding forest practices is one of the most important aspects of forest management. This paper aims to elaborate stakeholders' perception on the biophysical, socio-economic and institutional aspects of forest landscape management in upstream Ciliwung watershed. Data were collected through survey, by highlighting preferences, perceptions, and expectations of actors who are interested in the impacts of watershed management. This study indicates that communities at upstream Ciliwung watershed area perceived that the socio-economic aspect is the most important factor in managing upstream Ciliwung watershed. The governments (central and local), however, pay more attention to the biophysical and institutional aspects. The result of the overall perception analysis shows that institutional aspects need to be addressed first, followed by socio-economic aspects and biophysical aspects to improve the management of upstream Ciliwung watershed. Addressing institutional aspects is needed to enhance awareness and coordination among stakeholders, to enforce law and to develop a monitoring system to support the preservation of the forest at the upstream watershed areas. In terms of socio-economic aspects, improving community livelihoods is needed through payments for environmental services. Regarding biophysical aspects, afforestation and conservation of soil and water need to be prioritised. Thus, there should be programs that could provide solutions based on the three main aspects to improve the management of the forest resources in the upstream watershed area.

Keywords: Watershed management, stakeholder perception, community, institutions

PERSEPSI PARA PEMANGKU KEPENTINGAN TERKAIT PENGELOLAAN DAS CILIWUNG HULU: IMPLIKASI TERHADAP PERENCANAAN LANSEKAP HUTAN. Hutan memiliki peranan yang sangat penting baik bagi masyarakat pedesaan maupun perkotaan. Mengakomodir berbagai persepsi para pengguna hutan terhadap praktik-praktik pemanfaatan hutan merupakan salah satu aspek yang paling penting dalam pengelolaan hutan. Tulisan ini bertujuan untuk menguraikan bagaimana persepsi para pemangku kepentingan terhadap aspek biofisik, sosial ekonomi, dan kelembagaan dalam pengelolaan lansekap hutan di DAS Ciliwung hulu. Pengumpulan data dilakukan melalui survey dengan menggali preferensi, persepsi, dan harapan-harapan pihak-pihak yang memiliki kepentingan dan juga yang terkena dampak dalam pengelolaan DAS Ciliwung hulu. Hasil studi menunjukkan bahwa menurut masyarakat DAS Ciliwung hulu aspek sosial ekonomi adalah faktor yang paling penting dalam mengelola hulu DAS Ciliwung. Di sisi lain, pemerintah baik pusat maupun daerah memiliki persepsi bahwa aspek biofisik dan kelembagaan yang lebih utama. Namun demikian, berdasarkan hasil analisis secara keseluruhan menunjukkan bahwa aspek kelembagaan merupakan prioritas utama yang harus dibenahi, diikuti oleh aspek sosial ekonomi dan aspek biofisik dalam memperbaiki pengelolaan DAS Ciliwung hulu. Upaya mengatasi aspek kelembagaan sangat diperlukan untuk meningkatkan kesadaran dan koordinasi antar pemangku kepentingan, menegakkan hukum, dan mengembangkan sistem pemantauan dalam upaya pelestarian hutan di wilayah hulu DAS. Dari aspek sosial ekonomi, upaya peningkatan mata pencaharian masyarakat di daerah hulu DAS Ciliwung sangat diperlukan melalui pembayaran jasa lingkungan. Sementara itu terkait dengan aspek biofisik, kegiatan penghijauan dan konservasi tanah dan air di DAS Ciliwung hulu perlu diprioritaskan. Dengan demikian diperlukan

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program yang dapat memberikan solusi berdasarkan tiga aspek utama untuk meningkatkan pengelolaan sumberdaya hutan di daerah DAS Ciliwung hulu.

Kata kunci: Pengelolaan DAS, persepsi para pemangku kepentingan, masyarakat, kelembagaan

I. INTRODUCTION

The potential losses of forests and water resources are serious issues worldwide, and it becomes more crucial with limited understanding of the processes that lead to improvements in or deterioration of natural resources (Ostrom, 2009). The implementation of natural resource utilisation will affect land uses (Asdak, 2010). Therefore, land use planning is very important as a key instrument on sustainable development (Bourgoin, 2012). Asdak (2010) stated that the impacts of interaction between human and natural resources are beyond political boundaries. For example, flooding caused by activities of humans at the upstream watershed area, that are not managed according to conservation principles, would inundate the downstream region disregarding political or administrative boundaries. It means that a good resource management conducted by a party cannot be always considered as a good practice by others (Iqbal, 2007; Race & Millar, 2008). This is because the disruption of a component of the natural system will influence other components. Therefore, a good natural resource management needs to consider ecological, social and economic factors (Asdak, 2010). Ecological, social and economic factors have been influencing public perception on forest management in the upstream watershed in a different way (Stojanovska, Blazevska, Stojanovski, & Nedanovska, 2012).

Unintegrated forest-driven water into regional and national decision making on land use and water management will constrain humanity's ability to protect our life-sustaining functions (Ellison et al., 2017). Furthermore, Ellison et al. (2017) stated that forests and trees must be recognized as prime regulator within the water cycles. It indicates that forest management at the upstream watershed is an important part for regulating water flow throughout the watershed area and the reduction of forest cover will affect the process of rainfall infiltration and subsequent groundwater recharge (Krupnik & Jenkins, 2006). Furthermore, Krupik and Jenkins (2006) stated that the decrease of forest cover causes the increase of surface flow (runoff) during the rainy season. Despite an increase in annual runoff, the lack of ground water recharge can result in significantly reduced dry season flows (Gene, Lickens, Boorman, Johnson, & Pierce, 1970). Thus, it shows that forest management in the upstream areas has an important role in supporting the life of people at downstream areas, where they highly depend on the sufficiency of clean water from the upstream area. To manage the forests effectively without ignoring the rules of environmental protection, it is very important to know the involvement of local forest users and other stakeholders and to consider their perceptions on forest management (Stojanovska et al., 2012). So that, the manager will be aware of the most influential stakeholders and set the strategy for stakeholder's management in the future (Aragones-Beltran, Garcia-Melon, & Montesinoe-Valera, 2017). However, changes for the better cannot occur without significant changes in human behaviour and perceptions (Voinov et al., 2016).

According to Allen et al. (2009) besides behaviour, values and beliefs are critical component of the human dimension of natural resources management and they must be considered in the planning processes. Meanwhile, perception is one of three basic dimensions that help explain stakeholders' behaviour (Herman & Thissen, 2009). Robbin and Stephen (2003) stated that stakeholders'

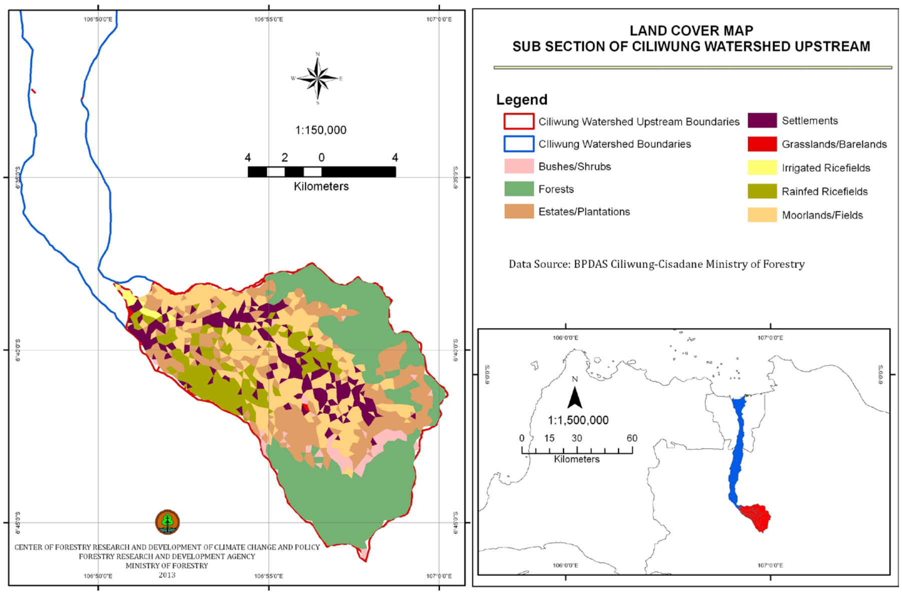

Figure 1. Land cover of upstream Ciliwung Watershed

perception of a resource utilisation is a basic problem in forest management. This is because stakeholders' perceptions or responses have an important role in creating policies and plans to achieve sustainable forest management. The management of forest resources has always been important to many aspects of human life (Stojanovska et al., 2012). Meo et al. (2011) stated that management of natural resources often creates conflict of interests among various parties because they use the same resources for different purposes. It also raises new challenges because of the diverse characteristics, interests and goals of the different stakeholders involved (Kazadi, Lievens, & Mahr, 2016). Stojanovska et al. (2012) also suggested that the diversity of ecological, social and economical factors may lead to the varieties of stakeholders' perceptions throughout the world.

Thus, it is very important to know different perspectives of resource management - especially in the upstream Ciliwung watershed - based on the perceptions of the actors. The upstream area of Ciliwung watershed has been chosen as the case study because it constitutes one of the critical watersheds in Indonesia and is prioritised by the Ministry of Forestry, currently named Ministry of Environment and Forestry, to be managed sustainably. The watershed plays an important role for the daily life of millions of people, especially the communities in the downstream area of Jakarta. As the country's capital city, Jakarta is the centre of national economy where the physical development tends to degrade the carrying capacity of the landscape. In addition, understanding the perceptions of stakeholders could help policy makers and forest planners in developing a better policy for natural resources at the national level (Meo et al., 2011).

This study aims to analyse and illustrate perceptions of community and government agency stakeholders related to the existing biophysical, socio-economic, and institutional conditions of forest management in the middle and upstream Ciliwung watershed. This research is expected to provide information related to how the stakeholders actually perceive and improve the forest management of upstream Ciliwung Watershed.

II. CHARACTERISTICS OF UPSTREAM CILIWUNG WATERSHED

Based on the data from the Ministry of Forestry (2013), total land area of Ciliwung Watershed was about 38,610 ha. It is reported

Table 1. The proportion of grant and activities program

No.	Local Government (District/City)	Grant (%)	Activities Program
1.	Bogor	9.88	Bioretention, biopori, controlling villas, absorption wells, dams
2.	Bogor (City)	12.34	Absorption wells, infrastructure
3.	Depok	15.99	'situ' repair, absorption wells
4.	Tangerang	9.26	Dock construction
5.	Tangerang (City)	12.61	Drainage improvements, construction of roads and bridges
6.	Tangerang Selatan (City)	12.04	Drainage improvements, roads, absorption wells
7.	Bekasi	11.59	Repair of roads and bridges
8.	Bekasi (City)	8.20	Road repair and building levee
9.	Cianjur	8.09	Reforestation, dams, absorption wells

Table 1 shows that almost 100% of the funds are distributed to the districts/cities for the physical rehabilitation and only small portions were allocated for planting at the upstream (Cianjur District).

that 50.35% of that area (19,441 ha) has been allocated for settlement and 45% (17,325 ha) are covered by vegetation. From the total of the vegetated areas, only 9.5% are considered as forest, while the rest is dominated by farming crops.

At the upstream watershed, the forest cover can now only be found in protection forests and it tends to degrade further because the forests have been converted into settlements and plantations. The land use changes at the upstream Ciliwung Watershed have happened since 1981 either in legal or illegal ways (Suwarno et al., 2011). Responding to this situation, several attempts have been conducted such as issuing of the Presidential Decree No. 114 of 1999, followed up by Presidential Regulation No. 54 of 2008 on the management of land use of Jakarta, Bogor, Depok, Tangerang, Bekasi, Puncak and Cianjur. Furthermore, upstream Ciliwung Watershed has been included as a national strategic area. However, those efforts have not significantly improved the watershed conditions due to internal problem of the government, poor coordination, and strong vested interests (Suwarno et al., 2011). Figure 1 shows that the upstream watershed has been dominated by settlements, plantations and agriculture land.

Suwarno, et al. (2011) stated that the problems in the Ciliwung Watershed, which caused flooding in Jakarta every year, are resulted from the accumulation of socio-economic and institutional problems. In socio-economic aspects, human resource competencies, population density and the level of community's welfare are the main problems. The next is institutional problems. There is a lack of institutional capacity, lack of coordination among stakeholders that makes less integrated programs, lack of control and law enforcement functions, and spatial planning implementation is not appropriate. Furthermore, the Watershed Management Office (BPDAS) stated that the biophysical problems that occur in upper Ciliwung Watershed management are the impact of socio-economic and institution that have not been resolved.

Related to the improvement of Ciliwung Watershed management, in addition to the action plan, there are also already a cooperation between the government of Jakarta Province with the nine districts/cities surrounding Ciliwung Watershed comprising Bogor Regency, Bogor City, Depok City, Tangerang City, Tangerang Regency, South Tangerang Regency, Bekasi City, Bekasi Regency, and Cianjur Regency. This cooperation has been running since 2012 with a grant from Jakarta Provincial Government. The grant mechanism

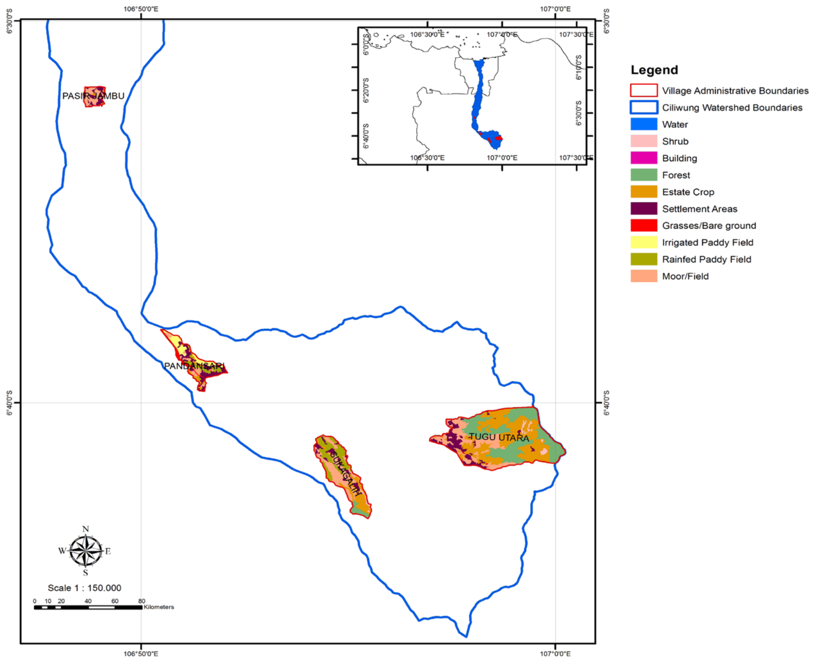

Figure 2. Map showing the study sites

is legalised through the Jakarta Governor Decree No. 127/2011 and No 62/2012 about Procedures for Grant, Social Assistance and Financial Aid from the Local Budget. In 2013, Jakarta Provincial Government has expended a grant of IDR 45 billion, allocated to repair the Ciliwung Watershed through some program activities as shown in Table 1.

II. MATERIAL AND METHOD

A. Selection of Research Area

This study has been carried out in four villages along Ciliwung Upstream, i.e. the village of Tugu Utara, Suka Galih, Pandansari and Pasir Jambu that are located in the middle and upstream of Ciliwung Watershed areas (Figure 2). These villages were chosen as the location of the study cases representing topographical variations of major land uses including smallholders' agriculture, plantations and settlements.

The communities of upstream Ciliwung watershed have agriculture practised for generations to support their lives . Respondents consisted of 60% male and 40% female with ages ranging between 20 and 55 years. The educational background of the respondents were 43% primary high school, 26% junior high school, 23% senior high school and 7% colleges. Meanwhile, the sources of livelihood of the communities were: farmers 51%, guards of villas 35%, and the remaining as employees and entrepreneurs. The farming system was supported by the fertile soil and good climatic conditions that made crops, such as vegetables, grow well. In addition, the availability of road and marketing network has encouraged people in the watershed upstream region to do agricultural activities.

B. Methods of Data Collection

Primary and secondary data were collected from April to December 2013. Primary data were gathered through interviews of key persons to provide a deeper analysis related to stakeholders' perception on upstream Ciliwung Watershed management. Open-ended and closed-questions were employed to highlight the preferences, perceptions, awareness, and expectations of stakeholders towards upstream Ciliwung Watershed management and general impacts of ongoing management of the watershed area. The open-ended questions were

Table 2. The governmental institutions

Governmental Institutions	Category of Agency
Watershed Management Office of Citarum-Ciliwung (Balai Pengelolaan Daerah Aliran Sungai/BPDAS Citarum-Ciliwung)	Central
River Management Authority of Ciliwung-Cisadane (Balai Besar Wilayah Sungai/ BBWS Ciliwung-Cisadane)	Central
Water Resources Managemant Office (Balai Pengelolaan Sumberdaya Air)	Local
Agriculture and Forestry Service of Bogor District (Dinas Pertanian dan Kehutanan Kabupaten Bogor	Local
Regional Development Planning Agency of Bogor District (Bappeda Kabupaten Bogor)	Local
Environmental Management Agency of Bogor District (Balai Lingkungan Hidup Daerah Kabupaten Bogor	Local
Environmental Management Agency of Bogor City (Balai Lingkungan Hidup Daerah Kota Bogor	Local
Bureau of Government Administration of Jakarta Province (Biro Tata Pemerintah DKI Jakarta	Regional
Regional Development Planning Agency of Jakarta (Bappeda Jakarta)	Regional
Buiding Management Office of Bogor Dictrict (Dinas Tata Bangunan Kabupaten Bogor)	Local
Sub-District Governments of Cisarua (Kecamatan Cisarua)	Local
Sub-District Governments of Megamendung (Kecamatan Megamendung)	Local
Sub-District Governments of Ciawi (Kecamatan Ciawi)	Local
Sub-District Governments of Pasir Jambu (Kecamatan Pasir Jambu)	Local
Tugu Utara Village (Desa Tugu Utara)	Local
Sukagalih Village (Desa Sukagalih)	Local
Pandansari Village (Desa Pandansari)	Local
Pasir Jambu Village (Desa Pasir Jambu)	Local

designed to allow respondents to expand their responses about current management practices in the upper Ciliwung Watershed. In addition, the closed questions were designed to explore the stakeholders' perceptions on the benefits of the watershed. Questions were designed to guide respondents in providing assessment for the existing watershed management based on three aspects namely: biophysical, socio-economic, and institutional. An overview of the current watershed conditions was obtained from the results of the field observations and opinions of the respondents who stated their perception using the previous open-ended questionnaires.

Stakeholder analysis was used in this study to determine stakeholders' involvement in the management of upstream Ciliwung Watershed. Stakeholder can be defined as individual, groups and organizations who are affected by or can affect those parts of policies, programs, and development activities (Bryson, 2003, 2004; Reed et al., 2009). Meanwhile, stakeholder analysis, according to Reed et al. (2009), is a process that defines social and natural phenomenon aspects affected by a decision or action; identifies individuals, groups and organisations who are affected by or can affect those parts of the phenomenon; and prioritises these individuals and groups for involvement in the decision-making process.

Identifying stakeholders is the first step in stakeholder analysis. Identifying stakeholders is an important part in this process to understand their interests and relationships. In this study the main stakeholders are: (1) government; and

Table 3. Criteria of biophysical, socio-economic, and institutional aspects in the management of upstream Ciliwung Watershed

Aspects	Criteria
Biophysical	1. Changes in land uses that do not comply with conservation principles 2. Poor condition of the upstream causes flooding in the downstream 3. Farming practices at the upstream areas do not comply with the principles of land conservation 4. Garbage or wastes are not managed properly 5. Poor condition of the upstream causes high sedimentation along the rivers 6. Lack of development of dams and canals at the downstream areas; those are not well implemented 7. Poor drainage system from upstream to downstream 8. Soil and water conservation needs to be improved 9. Tree planting activities need to be improved
Socio-Economic	1. Lack of involvement of local communities in the management of forest at the upstream area 2. Population growth resulting in a pressure on forests 3. Communities education level are still low 4. Rehabilitation activities haven't considered the economic interest of the community 5. Agricultural activities are significant in improving community's economy 6. Need to empower communities through household economic development programs 7. Local people's economic condition is low 8. Incentive mechanism from downstream to upstream is needed
Institutional	1. All activities in the upper watershed management have been efficiently and effectively implemented 2. The development of downstream area does not consider the environmental sustainability 3. Poor coordination among stakeholders in the upstream watershed management 4. Forest management program in the upstream Ciliwung is not focused 5. The implementation of spatial planning is still poor 6. The participation level of stakeholders in the management of upper Ciliwung is still low 7. Controlling system and law enforcement of land use management is still weak 8. The competency of human resources in managing upper watershed needs to be improved 9. Training to improve local communities' capacities are needed 10. Awareness raising activities to the community needs to be enhanced

(2) communities who live in the surrounding of Ciliwung upstream watershed. Other stakeholders are not considered as the main stakeholders since the focus of this study is on the impacts of policies on the communities. The government is a policy maker in the management of upstream Ciliwung watershed, while the communities are the stakeholders that are directly affected by and providing feedbacks on the policies associated with the management of the upstream watershed.

The respondents were selected through purposive sampling. In total, 54 key persons were selected covering 27 respondents from 19 governmental institutions and 27 community respondents -due to resource constraints- from 4 villages surrounding the watershed. The people as community respondents of the four villages were chosen due to their involvement in forest management in the upstream area of Ciliwung watershed. Meanwhile, the governmental institutions were chosen because they constitute

Table 4. Perception of local communities' on biophysical aspects

Criteria	Value (%)
Tree planting activities need to be improved	89
Soil and water conservation needs to be improved	85
Poor drainage system from upstream to downstream	78
Lack of dams and channels development at the downstream areas; those are not well implemented	71
Poor condition of the upstream causes high sedimentation along the rivers	70
Garbage or wastes are not properly managed	70
Farming practices at the upstream areas do not comply with the principles of land conservation	69
Poor condition of the upstream causes flooding in the downstream	66
Changes in land uses that do not comply with conservation principles	51

the relevant agencies who involved in the development of upstream Ciliwung watershed. The level of organization of stakeholders is very important to be identified because it helps explain which mechanisms are more dominant (Zavyalova, Pfarrer, Reger, & Hubbard, 2016). The governmental institutions are listed in Table 2.

The level of stakeholders' perceptions is measured by criteria related to biophysical, socio-economic, and institutional aspects using a Likert Scale (Table 3). The criteria were derived from (Stojanovska et al., 2012) who state that environmental, institutional, and social economic factors have been influencing public in a different way resulting with a permanent change on the public perception through the time. Furthermore, Stojanovska et al. (2012) say that the criteria are very important to be aware and take it into account to manage forests in accordance with the society needs and to have efficient forest policy and legislation. Meanwhile, the scale is one of the research instruments to measure opinion, perception, or attitude related to an object (Boone & Boone, 2012; Martono, 2015). Rating for each question within each aspect was asked. The rating used was: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. The value of respondent perception was obtained using the following formula: Index (%) = Total score/Y x 100, where: Total score is the sum of all respondents scores and Y is the highest score times number of respondents (Kiswari, Fathoni, & Minarsih, 2016). The value of index shows the prioritised criterion perceived by stakeholders. The higher the value the more prioritised is the criterion to be addressed.

In analysing the data, the perception of communities and government are separated. Tabulation and weighting are conducted for each criterion to produce a set of priority in managing upper Ciliwung Watershed. The results of weighting are then described using bar charts. To produce a total perception among respondents, the perception values of communities and government s are averaged. Lastly, a model of decision-making process was developed to aid government in determining steps for managing upstream Ciliwung Watershed.

III. RESULT AND DISCUSSION

A. Local Communities' Perception on Biophysical, Economic and Institutional Aspects

Data from open-ended interviews show that communities in the upper Ciliwung Watershed perceived that the biophysical conditions are poor due to land use changes such as the emergence of the construction of villas on the site and unsustainable farming, poor drainage, and improper management of wastes. It was

Table 5. Perception of local communities of socio-economic aspects

Criteria	Value (%)
Incentive mechanism from downstream to upstream is needed	89
Local people's economic condition is low	87
Need to empower communities through economic development programs of households	82
Agricultural activities are more significant in improving communities's economy	80
Rehabilitation activities haven't considered the economic interests of the communities	77
Communities education level are still low	76
Population growth resulting in a pressure on forests	75
Lack of involvement of local communities in the management of forest at the upstream area	69

Table 6. Perception of local communities of institutional aspects

Criteria	Value (%)
Awareness raising activities to the communities needs to be enhanced	85
Training to improve local communities' capacities are needed	85
The competency of human resources in managing upper watershed needs to be improved	84
Controlling system and law enforcement of land use management is still weak	82
The participation level of stakeholders in the management of upper Ciliwung is still low	80
The implementation of spatial planning is still poor	80
Forest management program in the upstream Ciliwung is not focused	78
Poor coordination among stakeholders in the upstream watershed management	78
The development of downstream area does not consider the environmental sustainability	76
All activities in the upper watershed management have been efficiently and effectively implemented	61

caused partly by the prevailing conditions where about 80% of communities' land has been sold to people from outside the villages. With only 20% of land ownership communities have no free choice to manage the land, because it's only enough to be used for their residence even sometimes without a yard.

From the closed-questionnaires it can be found that the local people want to plant trees or grow crops, but the new owners of that land prefer to build a villa. Although they tend to ignore the existing environmental conditions, which are no longer in accordance with its function, because of their limited access to the land and economic pressures, they realise that land rehabilitation through replanting program is needed to conserve soil and water resources. Table 4 describes the perceptions of local communities on the current situation of the biophysical aspects. In general, the perception reflects communities' awareness and willingness to sustainably manage the watershed area.

The perception of local communities on the biophysical aspects of the watershed is echoed by their perception on the socio-economic conditions as illustrated by Table 5. In Table 5, communities perceived that their welfare need to be improved, indicated by more than 75% of communities' perception encourage the increase of communities' welfare. From the survey, about 63% of communities only have 0 – 250 m^2 of land area. That piece of land is usually used for housing and farming. A household may consist of four to eight members with an average monthly income of Rp1,100,000. In addition, based on the educational level, most communities (43%) only attended primary school, 26% graduated from junior high school, 23% graduated from senior high school, and only 7% attended university (BPS, 2012). Thus, empowering communities through household economic development programs is needed. Furthermore, applying incentive mechanism from downstream to upstream, as a form of compensation for forest conservation would also help the programs. There are two main sources of income for respondents in that region: (1) farming; and (2) taking care of holiday villas. Farming crops and taking care of villas can provide an average income from Rp 400,000 to Rp 1,000,000 per month. Thus, the land use change in the upstream is not their concern as long as they earn enough money from the two substituting activities. For them, the reduction of income from farming could be compensated by income from maintaining villas.

On the institutional aspects, the communities strongly agree with the statement that the institutional arrangement of watershed management is still poor, indicated by a score that is more than 75%. Table 6 shows a strong agreement of the communities on the poor institutional arrangements of watershed management. Local communities felt that it is important to improve the capacity of local communities through training to develop their competency. It is inline with Evans et al. (2010) who said that the local communities need to develop skills to achieve their goals. They also felt that coordination and cooperation among stakeholders in the management of upper Ciliwung Watershed is still poor and the law enforcement is still low. Meanwhile the coordination and cooperation is very important to solve the problems that can bring changes to the management in the future (Aurenhammer, 2016).

B. Perceptions of Governments on Biophysical, Economic and Institutional Aspects

According to Stojanovska et al. (2012), in the long run the sustainability of forests can determine the viability of watershed, society, and economy. To achieve the sustainability, it is necessary to build an integrated collaboration among government agencies. Perception of various government agencies is one of the fundamental factors to be able to develop a better management plan and it is important to understand the formal and informal interests of stakeholders to evaluate the implementation of regulations (Nurrochmat, Dharmawan, Obidzinski, Dermawan, & Erbaugh, 2016). The perceptions of government on the current situation of biophysical aspects of Ciliwung Watershed are illustrated in Table 7.

According to the government's perception on Table 7, tree planting and conservation of

Table 7. Perception of Government officials on biophysical aspects

Criteria	Value (%)
Tree planting activities need to be improved	91
Soil and water conservation needs to be improved	89
Poor drainage system from upstream to downstream	75
Poor condition of the upstream causes high sedimentation along the rivers	74
Garbage or wastes are not properly managed	74
Changes in land uses that do not comply with conservation principles	72
Poor condition of the upstream causes flooding in the downstream	69
Farming practices at the upstream areas do not comply with the principles of land conservation	68
Lack of dams and channels development at the downstream areas; those are not well implemented	65

Table 8. Perception of Government officials on socio-economic aspects

Criteria	Value (%)
Need to empower communities through economic development programs of the households	82
Incentive mechanism from downstream to upstream is needed	78
Population growth resulting in a pressure on forests	74
Local people's economic condition is low	74
Agricultural activities are more significant in improving the economy of the communities	74
Communities education level are still low	72
Rehabilitation activities haven't considered the economic interests of the communities	68
Lack of involvement of local communities in the management of forest at the upstream area	62

soil and water were two major programs that should be prioritised in the management of upstream Ciliwung Watershed. The programs have been, actually, tried to be accommodated by the Ministry of Forestry through Watershed Management Agency (BPDAS) of Citarum-Ciliwung and the Ministry of Public Work through Balai Besar Wilayah Sungai (BBWS) Ciliwung-Cisadane. The BPDAS has developed a Management Action Plan of Ciliwung Watershed program covering an area of 370.8 km^2 from upstream to downstream. This action plan also covers some activities such as addressing the key issues that are very influential in the Ciliwung Watershed management, formulating action strategies that are rational, effective, efficient and implementable, and determining priorities and strategic actions of management activities based on time, location, cost and the role of parties.

There are two major programs that will be implemented by BPDAS in order to improve the biophysical conditions of Ciliwung Watershed namely: (1) vegetative action (i.e.: tree planting activities in the upstream of the watershed); and (2) civil engineering (i.e.: development of bio-retention, gully plug, dam, and water infiltration). These activities were targeted to be implemented from 2012 to 2016 at an estimated cost of about Rp 352 billion. Likewise, BBWS Ciliwung-Cisadane has also devised strategies and action plan that are documented in the Ciliwung- Cisadane Water Resources Management Pattern. This program has been implemented in the period 2012 to 2017. The programs of biophysical activities are river normalisation, dam and 'setu' revitalisation, construction of infiltration wells, and one of the great plans that will be executed from 2014 to 2017 is the construction of Ciawi Reservoir in Gadog Village, Bogor with a budget of Rp3.9 trillion. This study finds that the implementation of the program is usually slow due to bureaucratic and administrative compliances. This makes that program is not optimally implemented.

The government officers' perception on the socio-economic conditions as shown in Table 8 illustrates that the local government is still concerned with the socio-economic conditions of the communities, indicated by the highest score of 82%. One of the socio-economic programs has been led by the Agriculture and Forestry Office Bogor Regency through providing livestock such as cows or goats to selected farmer groups at several sub-districts using a rolling system. The government also considers the need for an economic stimulus for the upstream communities. The stimulus will be an incentive for the people who conserve the forests. The government perceived that the population density and limited employment opportunities in the upper Ciliwung Watershed are still unresolved issues and must be addressed

Table 9. Perception of Government officials on institutional aspects

Criteria	Value (%)
Awareness raising activities to the community needs to be enhanced	82
Poor coordination among stakeholders in the upstream watershed management	80
Training to improve capacities of local communities is needed	78
Controlling system and law enforcement of land use management is still weak	78
The competency of human resources in managing upper watershed needs to be improved	77
The development of downstream area does not consider the environmental sustainability	74
The implementation of spatial planning is still poor	74
The participation level of stakeholders in the management of upper Ciliwung is still low	72
All activities in the upper watershed management have been efficiently and effectively implemented	69
Forest management program in the upstream Ciliwung is not focused	68

in the management of Ciliwung Watershed.

Hence, it means the government officials agreed that participation of the local communities is very important to protect and regenerate forests by rehabilitating the forests through replanting activities. They also agreed that forest protection is possible only when the socio-economic conditions of the villages are improved. From the institutional side as shown in Table 9 the relationships among stakeholders is still a fundamental problem in the management of Ciliwung Watershed. This is illustrated by government official's strong agreement (80%) on the statement. Thus, a good coordination between agencies in Ciliwung Watershed management has not been established yet, besides the lack of raising awareness of the communities (82%). Most of respondents think that it is very important to improve mutual relations and understanding among stakeholders. Some respondents also felt that the relations of the official government with the people have improved but it is still not satisfactory.

The perceptions of communities and government officials on the management of watershed are compared according to biophysical, socio-economic and institutional aspects as shown in Figure 3. According to communities, the socio-economic issues are the most influential factors that cause the degradation of upstream Ciliwung Watershed. The second issue is the institutional problems because they felt less involved in the rehabilitation activities carried out by the government. However, related to the biophysical issues, the communities are not concerned. This is in contrast with the perception of the government agencies, who perceived biophysical and institutional aspects as the main issues and the most important factors to be addressed and the socio-economic aspects as the last issue to be concerned. The differences reflect different in orientation, interests, and priorities for daily life. Their financial limitations lead communities to prioritise the fulfilment of their basic needs compared to addressing biophysical and institutional problems. On the other side, government officers usually have a better life and are responsible for the improvement of the watershed.

Thus, the communities want to improve the standard of living as a priority in the management of upstream Ciliwung watershed. On the other hand, the government considers that the biophysical and institutional conditions are the top priorities in the upstream watershed management that will lead to the improvement of socio-economic conditions. This is due to the differences of interests between communities

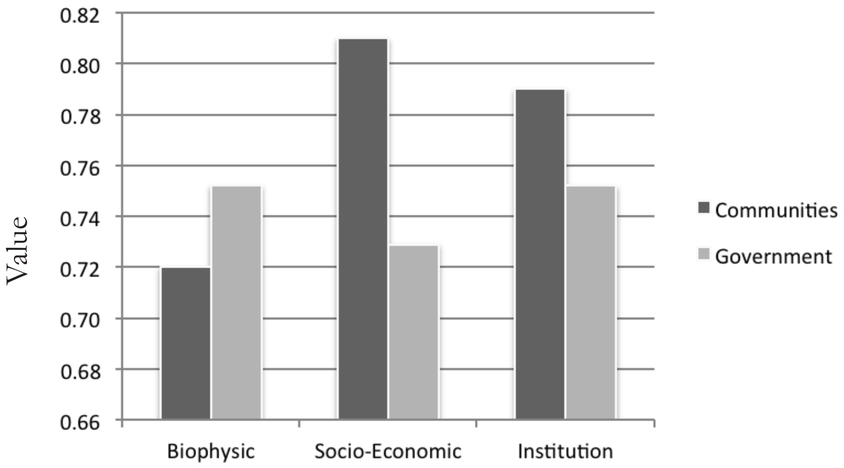

Figure 3. Stakeholders' perception on the biophysical, socio-economic, and institutional aspects of Ciliwung Watershed management

and government agencies in terms of priority of the factors that need to be addressed in the Ciliwung watershed management. The authorities of Ciliwung watershed need to compromise their differences, as the best solution, to set up the top priority. One alternative to compromise over the different priorities of each party is by doing reconciliation. It can be done by averaging the scores of the same criteria of the two parties (communities and government). Figure 3 shows how priorities can be established to compromise the differences between communities and governments' perceptions on the management of Ciliwung watershed.

Based on the discussions above, a model of decision-making process in the forest management of upper Ciliwung watershed can then be developed . A model can be developed to determine steps for decision making (Heyler, et al., 2016). In this research, the model was developed based on a compromise over differences of two parties. It is acknowledged that the successful management of the upstream watershed is not only influenced by the quality of the planning and implementation by the government, but also by the support of the surrounding communities which are the main stakeholders affected by any decision regarding the management of the watershed. Participation of communities in forest management in the implementation of a policy has increased over the last few decades (Hajjar & Kozak, 2015). Furthermore, Hajjar and Kozak (2015) stated that a trust between policy makers and communities is important to support forest management leading to a need for more trusted relationships prior to or while operationalizing new policies. A flow chart describing the decision-making process of watershed-based forest management is presented in Figure 4.

Figure 4 shows the process of decision making in the forest management of the upper Ciliwung watershed. Firstly, the main problem of the main priority in key success area should be determined. Determining these priorities is very important because it will lead to the direction of development and it is also the key to the success in management actions. Based on this study, the steps to determine the priorities in a watershed-based forest management comprise: (1) identify and categorise stakeholders, (2) develop a list of questions to explore perceptions of the management of each criteria consisting of institutional, socio-economic and biophysical aspects, (3) perform weightings of each of the questions in each criterion, (4) provide a rank for each criterion to determine the priority

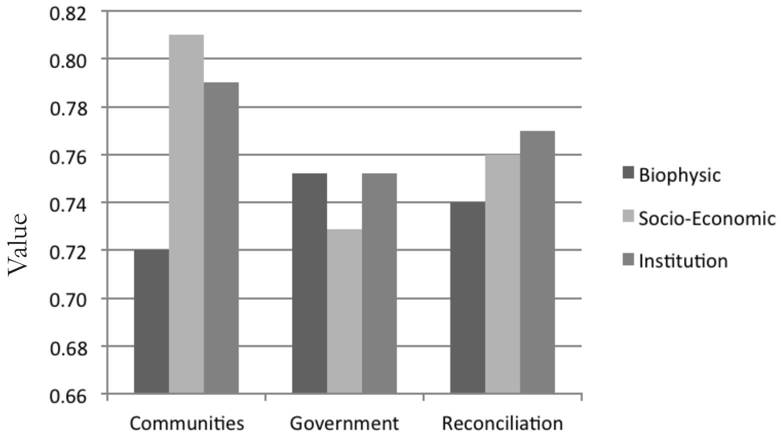

Figure 4. Proposed priorities to manage Ciliwung Watershed based on stakeholders' perceptions

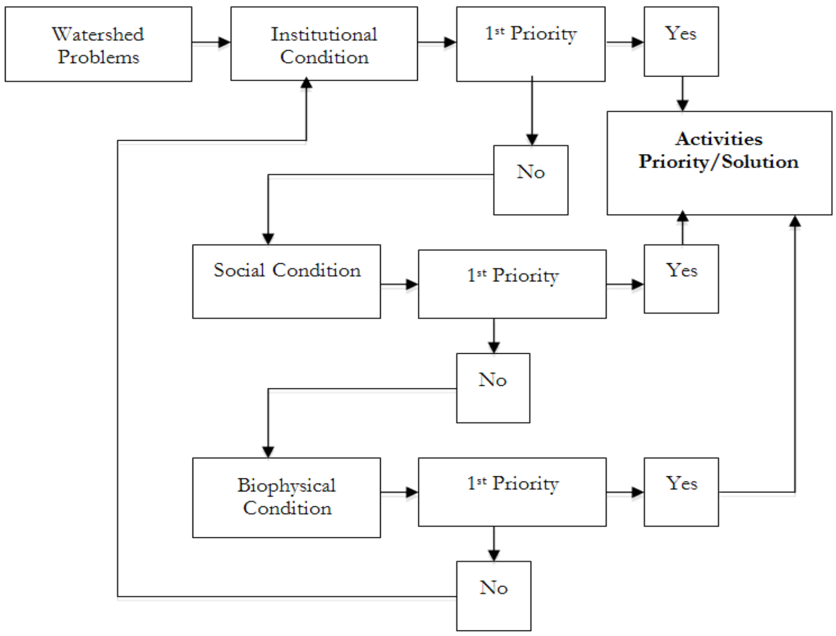

Figure 5. Procedures to make a decision based on the prioritised aspects of Ciliwung Watershed Management

in decision-making process, and (5) perform reconciliation or compromise as a solution to bridge the perception of each group of stakeholders.

IV. CONCLUSION

According to the analysis of stakeholders' perception on the management of upstream Ciliwung Watershed, the institutional aspect of the management is considered the most important aspect to be addressed. The features of institutional aspect that need to be prioritised include strategies for managing the watershed, awareness raising of communities, capacity building, law enforcement and monitoring land convertion activities. The second and third aspects to be addressed are socio-economic and biophysical aspects, respectively. Biophysical aspect becomes the last sequence of improving the management of Ciliwung Watershed because, in general, stakeholders agreed that biophysical problems (forests destruction in the upstream Ciliwung Watershed) are usually resulted by institutional and socio-economic problems that have not been resolved. In relation to socio-economic aspect, communities are more focused on how to obtain income to meet their daily needs rather than how to conserve resources along the watershed.

Hence, there should be programs that could provide solutions based on the three main aspects (institution, socio-economy, and biophysical condition) to improve the management of forest resources in the upstream watershed area. The solutions can be implemented in the form of: (1) strengthening the institutional arrangement and building capacity of both government and community; (2) increasing the economic development of community by providing 'incentives' for the upstream communities conserving forest resources in upper Ciliwung Watershed; and (3) prioritising institutional arrangements in improving the management of upper Ciliwung Watershed.

REFERENCES

Allen, S.D., Wickwar, D.A., Clark, F.P., Dow, R.R., R.Potts, & Snyder, S.A. (2009). *Values, beliefs, and attitudes technical guide for forest service land and resource management, planning, and decision making general technical report PNW-GTR-788*. U.S. Department of Agriculture: Pacific Northwest Research Station.

Aragones-Beltran, P., Garcia-Melon, M., & Montesinoe-Valera, J. (2017). How to assess stakeholders' influence in project management? A proposal based on the Analytic Network Process International *Journal of Project Management. 35* (3),451-462 doi:10.1016/j.ijproman.2017.01.001.

Asdak, C. (2010). *Hidrologi dan pengelolaan daerah aliran sungai*. Yogyakarta: Gajah Mada University Press.

Boone, H. N., & Boone, D. A. (2012). Analyzing likert data. *Journal of Extension*, *50*(2), 22-30.

Bourgoin, J. (2012). Sharpening the understanding of socio-ecological landscapes in participatory land-use planning. A case study in Lao PDR. *Applied Geogtaphy*, *34*, 99-110.

Bryson, J.M. (2003). *What to do when stakeholders matter: A guide to stakeholder identification and analysis techniques*. Washington, D.C : Georgetown University Public Policy Institute.

Bryson, J. M. (2004). What to do when stakeholders matter. *Public Management Review*, *6*(1), 21--53.

Ellison, D., Morris, C.E., Locatelli, B., Sheil, D., Cohen, J., Murdiyarso, D., . . . Sullivan, C.A. (2017). Trees, forests and water: Cool insights for a hot world. *Global Environmental Change*, *43*, 51-61.

Evans, K., Jong, W. D., Cronkleton, P., & Nghi, T.H. (2010). Participatory methods for planning the future in forest communities. *Society and Natural Resources*, *23*, 604-619.

Gene, E., Lickens, F., Boorman, F., Johnson, N., & Pierce. (1970). Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed-ecosystem. *Ecological Monographs*, *40*, 33-47.

Herman, L. M., & Thissen, W. A. H. (2009). Actor-actor analysis methods and their use for public policy analysists. *European Journal of Operational Research*, *196*, 808-818.

Iqbal, M. (2007). Analisis peran pemangku kepentingan dan implementasinya dalam pembangunan pertanian. *Jurnal Litbang Pertanian*, *26*(3), 1-11.

Kazadi, K., Lievens, A., & Mahr, D. (2016). Stakeholder co-creation during the innovation process: identifying capabilities for knowledge creation among multiple stakeholders. *Journal of Business Research*, *69*(2), 525-540.

Kementerian Kehutanan. (2013). Penyusunan Rencana Detil Penanganan Banjir di Wilayah Jabodetabekjur. *Laporan Penelitian* Balai Pengelolaan Daerah Aliran Sungai Citarum-Ciliwung.

Kiswari, Y., Fathoni, A., & Minarsih, M. M. (2016). Pengaruh kepuasan kerja, persepsi pegawai dan komitmen organisasi pegawai terhadap organizational citizenship behavior. *Journal of Management*, *2*(2), 1- 20

Krupnik, T. J., & Jenkins, M. W. (2006). *Linking farmer, forest and watershed: Agricultural systems and natural resources management along the upper Njoro River, Kenya*. Global, Area, & International Archive, University of California, Davis.

Martono, N. (2015). *Metode penelitian sosial*: *Konsep-*

konsep kunci. Jakarta: Rajagrafindo Persada.

Meo, I. D., Cantiani, M. G., Ferretti, F., & Paletto, A. (2011). Stakeholders' perception as support for forest landscape planning. *International Journal of Ecology*, *2011*, 685708, 1-8.

Nurrochmat, D.R., Dharmawan, A. H., Obidzinski, K., Dermawan, A., & Erbaugh, J. T. (2016). Contesting national and international forest regimes: Case of timber legality certification for community forests in Central Java, Indonesia. *Forest Policy and Economics*, *68*, 54-64.

Ostrom, E. (2009). A general framework for analyzing sustainability of Social-Ecological Systems. *Science*, *325*, 419. doi:10.1126/science.1172133

Race, D., & Millar, J. (2008). Social and community dimensions to ACIAR projects ACIAR. *Training Manual*. Australian Centre for International Agricultural Research, Canberra: Charles Sturt University.

Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., . . . Quinn, C. H. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management*, *90*, 1933–1949.

Robbins, & Stephen. (2003). *Perilaku organisasi*. Jakarta: Gramedia.

Stojanovska, M., Blazevska, A., Stojanovski, V., & Nedanovska, V. (2012). Perception of villagers from Ali Koch and Rastani towards forest management performed by the PE "Macedonian Forests". *South-east European forestry, 2*(2),73-79. doi:10.15177/seefor.11-08.

Voinov, A., Kolagani, N., McCall, M.K., Glynn, P.D., Kragt, M.E., Ostermann, F.O., . . . Ramu, P. (2016). Modelling with stakeholders - Next generation. *Environmental Modelling & Software*, *77*, 196-220.

Zavyalova, A., Pfarrer, M. D., Reger, R. K., & Hubbard, T. D. (2016). Reputation as a benefit and a burden? How stakeholders' organizational identification affects the role of reputation following a negative event. *Academy of Management Journal*, *59*(1), 253-276.

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CORRELATION ANALYSIS BETWEEN SEAWATER INTRUSION AND MANGROVE GREENBELT

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CORRELATION ANALYSIS BETWEEN SEAWATER INTRUSION AND MANGROVE GREENBELT. Seawater intrusion is an entry process of seawater to land. Many factors have caused seawater intrusion from freshwater exploitation until mangrove degradation. Mangrove ecosystem is a type of forest ecosystem which has an ability to reduce seawater intrusion. This paper analyzes the estimation and prediction of seawater intrusion and correlation between widths of mangrove with seawater intrusion. The relation analysis between the width of mangrove greenbelt with seawater intrusion used an equation model to predict seawater intrusion. The research method used sampling technique, system analysis with powersim software, correlation analysis and mathematical method with trend line analysis. Results show that (1) the mangrove density in the coastal area is approximately 50 – 109 trees/ha. (2) Simulation results showed seawater intrusion rate was about 0.20 km year^{-1} (with mangrove as a component system), but reached 0.3 – 0.4 km/year (without mangrove as a component system). (3) The simulation result also showed that freshwater salinity was estimated to increase from 1.92 ppt to 4.86 ppt. (4) The relation model between seawater intrusion and mangrove greenbelt showed that correlation coefficient was 0.97 with the equation seawater intrusion (m) = 2264.9 * exp (-0.009 * the width of mangrove greenbelt (m)), the correlation of mangrove width with seawater intrusion was 0.97. (5) *Avicennia marina*, *Avicennia alba*, *Rhizophora styllosa*, *Sonneratia alba* and *Sonneratia caseolaris* were the mangrove species that had the best ability to reduce seawater intrusion.

Keywords: Seawater intrusion, mangrove, water salinity, system analysis

*ANALISIS KORELASI ANTARA INTRUSI AIR LAUT DENGAN JALUR HIJAU MANGROVE. Intrusi air laut merupakan proses masuknya air laut ke daratan. Faktor-faktor yang menyebabkan terjadinya intrusi air laut diantaranya adalah pemompaan air tawar hingga kerusakan ekosistem mangrove. Ekosistem mangrove adalah suatu ekosistem yang memiliki kemampuan untuk mengurangi proses intrusi air laut. Penelitian ini menganalisis pendugaan dan prediksi intrusi air laut, hubungan antara lebar jalur hijau mangrove dengan intrusi air laut. Analisis hubungan antara lebar jalur hijau dan intrusi air laut menggunakan suatu model persamaan. Penelitian ini dibangun dengan menggunakan pendekatan teknik sampling, analisis sistem dengan powersim, analisis korelasi, analisis matematika dengan menggunakan "trendline". Hasil dari penelitian ini adalah (1) potensi kerapatan mangrove adalah sekitar 50 – 109 pohon/hektar. (2) hasil simulasi menunjukan laju intrusi air laut jika ada mangrove mencapai 0,20 km/tahun, tapi jika tidak ada mangrove mencapai 0,3 – 0,4 km/tahun. (3) hasil simulasi menunjukan bahwasalinitas air tawar diduga meningkat dari 1,92 ppt hingga 4,86 ppt. (4) dari model hubungan antara intrusi air laut dan lebar jalur hijau menunjukan koefisien korelasi sekitar 0,97 dengan persamaan pendugaan intrusi air laut adalah 2264,9 * exp (-0,009 * lebar jalur hijau mangrove (m)), (5) jenis-jenis* Avicennia marina, Avicennia alba, Rhizophora styllosa, Sonneratia alba *dan* Sonneratia caseolaris *merupakan jenis mangrove yang memiliki kemampuan terbaik untuk mengurangi intrusi air laut.*

Kata kunci : Intrusi air laut, mangrove, salinitas air, analisis sistem

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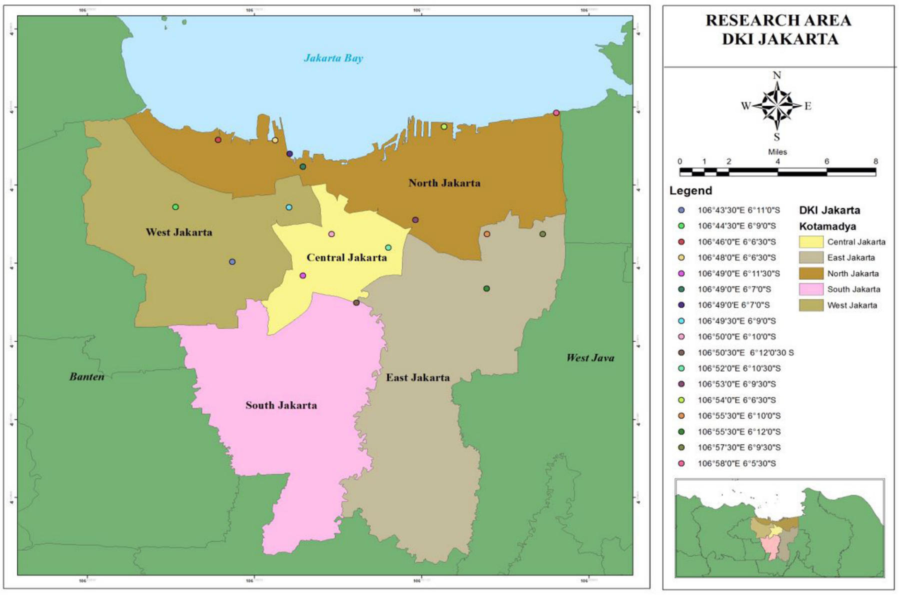
I. INTRODUCTION

Seawater intrusion occurs as an impact of mangrove degradation, seawater expansion and freshwater exploitation toward unbalanced potential of freshwater in the coastal ecosystem (Andrari, Nandang, Masmui & Priyono, 1996). The high exploitation of freshwater, as a desirable source of water, to support different domestic activity (Hussain, Javadi, & Sherif, 2015), industrial and agricultural sectors and pumping of groundwater (Hussain et al., 2015) are critical factors of seawater intrusion in Jakarta. The other factors are population growth, land use changes and urbanization that have also increased the pressure on the source of freshwater to the extent leading to the extraction of groundwater as the alternative to surface water to cope with the scarcity of freshwater resources (Narayan, Schleeberger & Bristow, 2007). Seawater intrusion usually occurs due to rapid disturbances which give negative impact for coastal sustainability as a risk to coastal aquifers in the coastal area (Morgan & Wernera, 2015). Seawater extent represents the condition of the respective aquifers under stress (Morgan & Wernera, 2015).

The worst effects of seawater intrusion for environment are reduction of freshwater, agriculture degradation, increasing water salinity, soil degradation (Badarudeen, Damodaran, Sajan & Padmala, 1996), destruction of water gradient, and unbalance in freshwater potential (Todd 1980). The seawater intrusion in Jakarta is a specific case of seawater intrusion in Indonesia. The high degradation and deforestation of mangrove ecosystem causes increased freshwater degradation and also the degradation of soil physic is another causing factor of seawater intrusion. This condition shows that mangrove vegetation has the function of retaining and reducing the potential and effect of seawater intrusion (Ellison & Farmsworth, 1997; Kairo, Dahdouh-Guebas, Bosire & Koedam, 2001).

Mangrove in Jakarta has many functions, for example, buffering of coastal area, habitat of flora and fauna and reduction of seawater intrusion. However, the important functions of mangrove ecosystem are the preservation of habitat for spawning, representing nursery and feeding grounds for several aquatic organisms (Nagelkerken et al., 2008; Kusmana, 2005; Hutchings & Saenger, 1987; Snedaker & Snedaker, 1984), reducing and retaining heavy metal pollution (Machado, Moscatelli & Rezende, 2002; Hilmi et al., 2014), reducing abrasion (Cai, Su, Liu, Li, & Lei, 2009; Hilmi 2014), reducing of tidal wave effect (Mazda, Kanazawa & Wolanski, 1995; Massel, Furukawa & Brinkman, 1999), and buffering of coastal stabilities (Mazda et al., 1995). To support this function, the mangrove ecosystem has the specific vegetations that are growing to interface between terrestrial and ocean ecosystem (Kusmana, 2005; Kathiresan & Bingham, 2001; Parvaresh et al., 2011; Hilmi, Syakti & Siregar, 2014). But, an important function of the mangrove in Jakarta is the function to reduce seawater intrusion.

The mangrove ecosystem has ability to reduce seawater intrusion because mangrove can eliminate the effect of salinity, pH, pyrites and anaerobe conditions. The mangrove ecosystem also has salt-excreting gland, salt-accumulating gland and salt-excluder gland (Bengen & Dutton, 2004), specific root (Alongi, Wattayakorn, & Boyle, 2004), root activity, salinity absorption, salinity accumulation, specific growth (Lunstrum & Chen, 2014) and another metabolism to reduce impact of seawater in mangrove metabolism. Therefore, the degradation and deforestation of mangrove ecosystem causing reduction of the mangrove function to reduce seawater intrusion. The objective of this research is to simulate correlation between seawater intrusion with the width of mangrove ecosystem. The research used Stella software, trend line analysis and datafit analysis.



Remarks: O= sampling plots

Figure 1. Research sites

II. MATERIAL AND METHOD

A. Study Site

This research was conducted in North Jakarta (Figure 1). The research area is part of the coastal ecosystem (5°19'12" South Latitude (N) – 6°23'54" South Latitude (S) and 106°22'42' East Longitude (W) – 106 °58'18" East Longitude (E)) as the estuarine ecosystem to support water distribution from *Angke, Ciliwung*, and Cisadane rivers, as well as the North Java Ocean. Seawater intrusion is a big problem in North Jakarta. The high exploitation of freshwater with pumps and mangrove degradation (Hilmi, 1998) were the triggering factors of seawater intrusion. The locations of research for analysis of mangrove domination were Greenbelt North Jakarta, *Suaka Margasatwa Muara Angke*, and Ecotourism in North Jakarta and Silvofishery Area in North Jakarta. The sampling plots were U1 (106°43'30"E – 06°11'00"S), U2 (106°44'30"E – 06°09'00"S), U3 (106°46'00"E – 06°06'30"S), U4 (106°48'00"E – 06°06'30"S), U5 (106°49'00"E – 06°11'30"S), U6 (106°49'00"E – 06°07'00"S), U8 (106°49'10"E – 06°07'00"S), U9 (106°49'30"E – 06°09'00"S), U10 (106°50'00"E – 06°10'00"S), U11 (106°50'30"E – 06°12'30"S),U12 (106°52'00"E – 06°10'30"S), U12 (106°53'00"E – 06°09'30"S), U13 (106°54'00"E – 06°06'30"S), U14 (106°55'30"E – 06°10'00"S), U15 (106°55'30"E – 06°2'00"S), U16 (106°57'30"E – 06°09'30"S), U17 (106°58'00"E – 06°05'30"S).

B. Research Procedures

1. Research Variables

The variables of seawater intrusion were the distance of seawater intrusion, water quality, water salinity, soil porosity, the density of mangrove ecosystem, and the width of mangrove greenbelt.

2. Sampling Technique

The collection of research data used clusters with stratified sampling (Cochran, 1997) following the density of mangrove. The sampling design to observe the density of mangrove, the area of mangrove ecosystem, water salinity, distance of seawater, soil properties and the width of mangrove greenbelt used 17 sampling stations with three

Table 1. Standard criteria of mangrove degradation (Ministry of Environment Decree No 2004)

Degradation class	Density criteria	Mangrove coverage	Mangrove density level (trees/ha)
No degradation	Dense	≥ 75	≥ 1500
	moderate	≥ 50-≥ 75	≥ 1000 - < 1500
Degradation	rare	< 50	< 1000

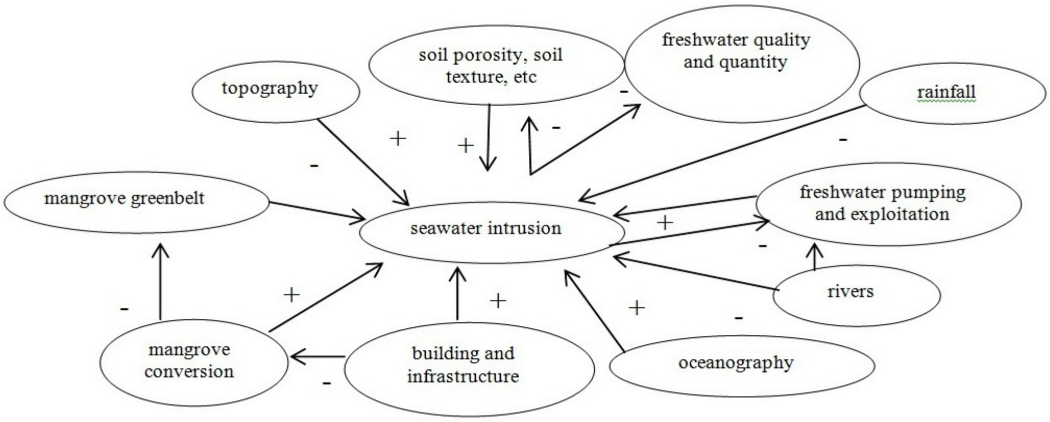


Figure 2. Causal loop modeling of seawater intrusion

replications. The number of sampling plots were (1) North Jakarta (7 stations), (2) West Jakarta (3 stations), (3) Central Jakarta (3 stations) (4) East Jakarta (3 stations) and (5) South Jakarta (only one station).

3. Width and Area of Mangrove Greenbelt

The research procedure to analyze the width and the potential area of mangrove greenbelt used geographical information system (Prahasta, 2008; Purwadhi 2001) to overlay satellite imageries for 1980, 2000, 2010, and 2016. The satellite imagery interpretation used ERR mapper software. After interpreting with ERR mapper, the width and mangrove area was analyzed by Arc GIS 9.1.

4. Mangrove Density

The density of mangrove ecosystem (collection of all species) used the modification of quadrant transect method (Kusmana, 1997). The collection of data used plot sizes of 10 m x 10 m for mangrove trees, 5 m x 5 m for mangrove saplings and 2 m x 2 m for mangrove seedlings. These activities were carried out in Greenbelt North Jakarta, Suaka Margasatwa Muara Angke, Ecotourism in North Jakarta, Silvofishery Area in North Jakarta and other areas as research stations. To calculate the density of mangrove the equation below was used (Kusmana, 1997; Bengen, 2002).

$$Di = \frac{ni}{A} \qquad (1)$$

Where:

Di = density, *ni* = number of individuals (seedlings, saplings and trees) and *A* = mangrove area (ha)

For degradation of mangrove ecosystem the mangrove degradation criteria was used from Menteri Lingkungan Hidup No. 201 in 2004 (Table 1) which was divided into degraded and not degraded.

5. **Water Salinity, Soil Salinity and Soil Porosity**

The measurement of water salinity used APHA (2005) method with hand refractometer. The measurement of soil texture used gravimetric method. The soil analysis was done at the Soil Laboratory of Land Resources and Soil Departement, Bogor Agricultural University (Soil Research Department, 2005).

6. **Potential of Seawater Intrusion**

The measurement of seawater intrusion distances used water salinity method in the water pump with hand refractometer. The sampling points of water salinity were marked by global positioning system to measure the distance of seawater intrusion (km).

C. Data Analysis

1. Mapping of Mangrove Greenbelt

The mapping of mangrove greenbelt used Arc GIS 9.1 to overlay mangrove area from 1980, 2000, 2010 and 2016. These data were used to calculate mangrove area in Jakarta.

2. Modeling of Seawater Intrusion.

The seawater intrusion model used casual loop system among variables to develop the seawater intrusion model. The variables of causal loop system in this model were freshwater demand, oceanography effect, mangrove potency, river debits, runoff, rainfall, topography, and freshwater resource (Figure 2).

3. Modeling of Water Salinity

The modeling of water salinity used casual loop system among soil and water salinity. The variables of this model were Ca, Mg, Na, K, water salinity and pH in mangrove and other areas.

4. Relation between Mangrove Greenbelt and Seawater Intrusion

The relation between seawater intrusion and mangrove greenbelt used the trend line analysis l with the equation below (Steel & Torrie, 1980; Hilmi et al, 2014; Hilmi, 1998; Muhidin et al., 2011).

$$Y_{ij} = f\ (X_i) \quad (2)$$

Where:
Y_{ij} = distance of seawater intrusion (Km)
X_i = width of mangrove (m)
f = mathematic function (exponential, linier, etc.)

The trendline equation was a statistic method to construct and select the best equation of seawater intrusion. This equation interpreted the estimation and relation between the width of mangrove greenbelt and the distance of seawater intrusion.

III. RESULT AND DISCUSSION

A. Density of Mangrove Ecosystem

The garbage, domestic waste, agriculture waste, pollution of oils and heavy metals, deforestation and conversion of mangrove ecosystem were the triggering factors of the mangrove density (Hilmi, 1998) The mangrove density in Table 2 show the classification of mangrove density in Jakarta. Mangrove must have tolerance toward extensive erosion, abrasion (Paris et al., 2009), heavy metal pollution (Wang et al., 2012), soil sedimentation (Ferreira, Vidal-Torrado, Otero & Macias, 2010), seawater inundation, sea tide, garbage, pollution (Krauss et al., 2008), oceanography, freshwater supply (Finkl, 2004) and climate change (Robins et al., 2016) to live and grow in the coastal area of Jakarta. Mangrove has good grows when water salinity is between 10 – 30 ppt and pH is about 6-9 (Hutchings & Saenger, 1987; Snedaker & Snedaker, 1984) with soil textures which are sandy clay, clayey sand, silty sand, sandy silt, clayey silt, silty clay, clay, sand and silt (Pirzan, Gunarto, Daud & Burhanuddin, 2004).

Table 2 shows that the mangrove area in the greenbelt, ecotourism, and preservation areas of Muara Angke and Silvofishery had differences in density and species domination of the mangrove vegetation. Table 2 also shows that *Rhizophora apiculata*, *Rhizophora mucronata*, *Avicennia alba* and *Sonneratia alba* were the mangrove species dominating in North Jakarta,

Table 2. Mangrove density in Jakarta.

Mangrove Area	Species	Mangrove density (trees ha^{-1})			Class of forest degradation (Kusmana, 2005; Hilmi et al, 2011, KemenLH 201, 2004)
		Seedlings	Saplings	Trees	
Greenbelt North Jakarta	*Avicennia alba*	30000	2691	92	rare
	Rhizophora mucronata	40000	883	17	
Suaka Margasatwa Muara Angke	*Rhizophora apiculata*	2500	1000	0	rare
	Sonneratia alba	2000	1183	50	
Ecotourism in North Jakarta	*Avicennia alba*	30000	2773	127	rare - moderate
	Rhizophora apiculata	0	483	17	
	Rhizophora mucronata	13333	1350	50	
Silvofishery Area in North Jakarta	*Avicennia alba*	0	360	40	rare
	Rhizophora apiculata	0	252	15	
	Rhizophora mucronata	0	218	15	

because these species have the highest tolerance for garbage, domestic waste, oil, heavy metal and sea inundation. The mangrove density in Jakarta showed that (1) mangrove density in the greenbelt area was 1650 trees ha^{-1} (diameter > 4 cm) and 109 tree ha-1 (diameter > 10 cm) (rare), (2) *Suaka Margasatwa Muara Angke* had density about 433 trees ha^{-1} (diameter > 4 cm) and 50 trees ha^{-1} (diameter > 10 cm) (rare), (3) ecotourism area had density about 2800 trees ha^{-1} (diameter > 4 cm) and 194 trees ha^{-1} (diameter > 10 cm) (rare – moderate) and (4) silvofishery area had density of 900 trees ha^{-1} (diameter > 4 cm) and 70 trees ha^{-1} (diameter > 10 cm) (rare).

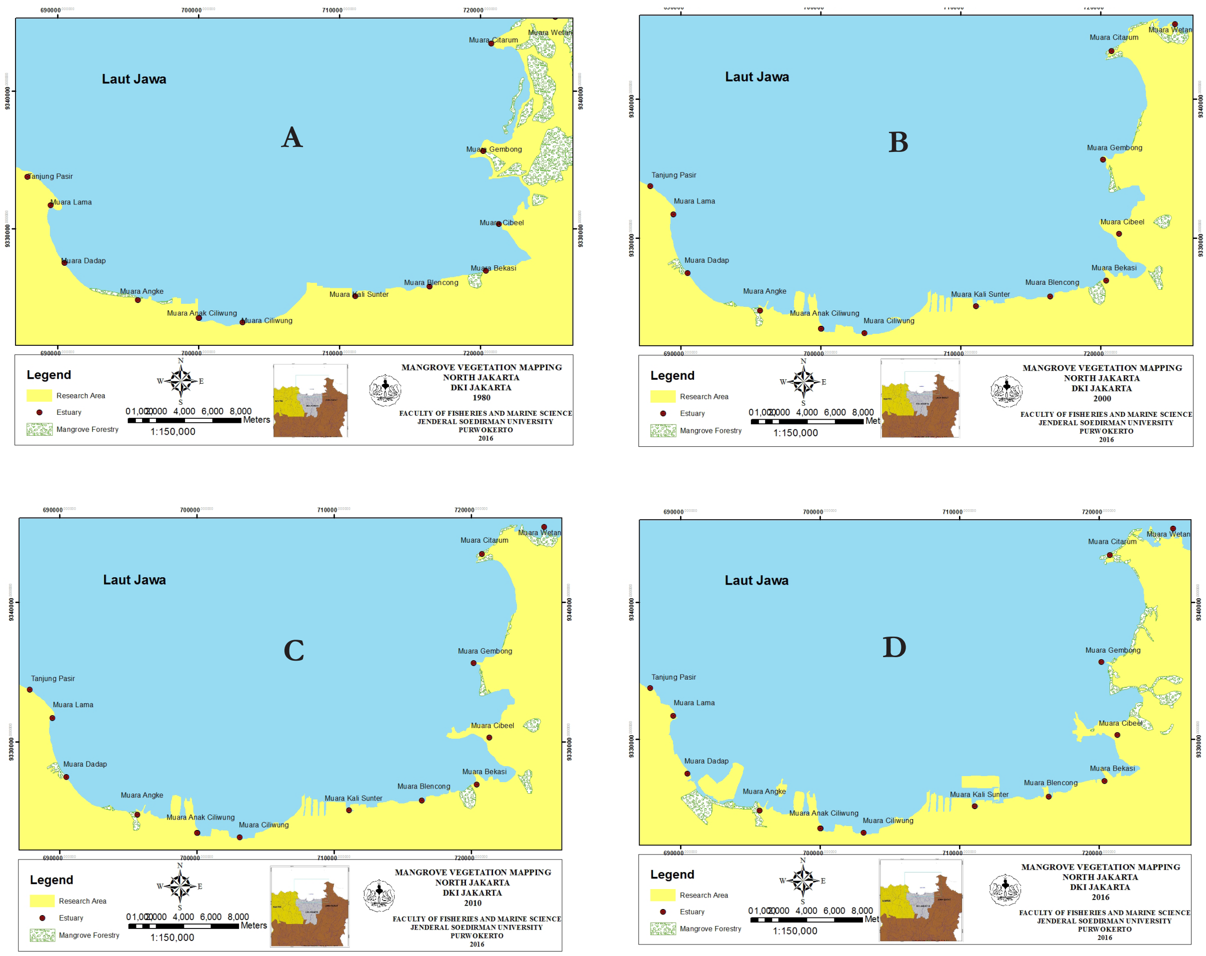
The low density of mangrove trees (Macintosh, Ashton, & Havanon, 2002) showed the degradation of mangrove ecosystem in Jakarta and had been categorized as rare – moderate density (Kusmana, 2005, Hilmi et al., 2011 and KLHK, 2004). Macintosh et al., (2002) noted that the main reason for the loss and degradation and deforestation of mangrove were population pressure, wood exploitation, mangrove conversion, sand mining and coastal conversion. Another factors effecting the density and stabilization of mangrove ecosystem were silviculture-oriented, economic and ecological conditions (Lunstrum & Chen, 2014).

In Jakarta, the degradation and deforestation of mangrove ecosystem were the key factors for seawater intrusion. The integration between deforestation and degradation of mangrove ecosystem with freshwater pumping, mangrove conversion, settlement, industry and hotel caused increasing seawater intrusion in Jakarta. The conversion of the mangrove ecosystem in Jakarta was a triggering factor for losing the role of the mangrove ecosystem to reduce seawater intrusion. The rate of mangrove degradation, conversion and mortality increasingly gave impact for reducing the function of mangrove as the buffer area to preserve coastal stabilization and to reduce negative impact of seawater intrusion.

Redesigning of rehabilitation and replanting activity of mangrove ecosystem aimed to reduce sea water intrusion based on the natural regeneration of mangrove species in North Jakarta. Basically, the mangrove ecosystem in Jakarta is going to do a succession process, because mangrove in Jakarta has 2000 – 40.000 individual/ha (seedlings) and 400 – 1.663

Table 3. Area of mangrove ecosystem in North Jakarta Coast

No.	Year	Mangrove Area (ha)
1.	1980	1165.33
2.	2000	168.00
3.	2010	171.35
4.	2016	165.28



Remarks:
A: North Jakarta Coast in 1980, C: North Jakarta Coast in 2010,
B: North Jakarta Coast in 2000, D: North Jakarta Coast in 2016

Figure 3. The trend of mangrove ecosystem in Jakarta

individual/ha (saplings). The maintenance activities of seedlings and saplings will make mangrove grow well. The activity of mangrove succession is an effort to support mangrove growth in the coastal area (Chebo, 2009; Kathiresan & Rajendran, 2005; Kusmana, 2005; Macintosh et al., 2002). The existence of seedlings and saplings of mangrove vegetation in the succession of mangrove must be conserved as the dynamic process of mangrove ecosystem to reach vegetation climax (Kusmana, 2005; Lopes et al., 2009; Macintosh et al., 2002).

The other activity to conserve mangrove

ecosystem in Jakarta was mangrove plantation (Kusmana, 2005). The mangrove plantation must see the complex and dynamic system of mangrove environment (Lopes et al., 2009). The mangrove plantation in Jakarta must select mangrove species based on best domination in Jakarta area, because these species have the best possibility to survive and density to support the successful mangrove rehabilitation. The species to support the rehabilitation program in mangrove ecosystem were: *Rhizophora apiculata*, *Rhizophora mucronata*, *Rhizophora stylossa*, *Avicennia alba*, *Sonneratia alba* and *Bruguiera* spp.

B. Dynamic Analysis of Mangrove Ecosystem

The dynamic of mangrove ecosystem showed the rate of mangrove regeneration and conversion (Table 3 and Figure 3). Based on data from 1997, the mangrove area in Jakarta was 322.6 ha (Hilmi, 1998) of which 169.9 ha was mangrove forest area and 152.7 ha was for other usage. The degradation rate of mangrove ecosystem reached 9.3% year. The biggest factor of mangrove degradation in Jakarta was the conversion of mangrove for settlement and other activity

Jakarta was moderate-high. The mangrove areas in Jakarta were 1165.33 ha (1980), 168 ha (2000), 171.35 ha (2010) and 165.28 ha (2016). These data also showed that the area in Jakarta decreased by 1000.05 ha (over 36 years) from 1165.33 ha (1980) to 165.28 ha (2016).

Table 2 and Figure 3 show that the rate of mangrove degradation and deforestation in Jakarta had a positive correlation with mangrove density (Table 1). The high rate of mangrove conversion and mortality were the key factors for mangrove density and degradation. Basically, the mangrove ecosystem has high sensitivity toward environment change and conversion. Sedimentation, garbage, industry and domestic waste, mangrove cutting and mangrove exploitation, freshwater flood, seawater flood and long inundation were the biggest factors of mangrove degradation and deforestation (Chebo, 2009; Krauss et al., 2008 and Xiao, Wang & Chen, 2010). The mangrove ecosystem was also sensitive and responsive toward climate change and human activity, the eco-geo-morphological processes and pressures (Al-Nasrawi, Jones & Hamilton, 2016). Therefore mangrove degradation and deforestation in Jakarta caused mangrove to stunt, dying, degradation of mangrove structure and mortality (Ellison & Farmsworth, 1997; Ellison, 2002).

The high mangrove degradation and deforestation also caused mangrove recovery and regeneration to be very difficult. Mangrove vegetation needs a long time to regenerate and recover to reach tree phase. The mangrove degradation was a triggering factor for coastal disasters including seawater intrusion. According to Salampessy et al., (2015), mangrove degradation, mangrove conversion, water unbalance and destruction of water gradient increased seawater intrusion in Jakarta. The conversion of mangrove ecosystem also was due to accelerated sea-level rise, seawater intrusion and land subsidence.

C. Prediction of Seawater Intrusion in Jakarta

Factors to predict seawater intrusion are: freshwater demand from industrial activity, settlement and hotel, sea tide, season, oceanographic, mangrove density, rivers' debit, source of freshwater and topography. Prediction of seawater intrusion in Jakarta with or without mangrove is shown in Table 4, Figure 4 and Figure 5. They show the existence of seawater in the coastal area, degradation of fresh water gradient, freshwater aquifer damage, and overexploitation of freshwater were the important factors of seawater intrusion in the coastal area of Jakarta (Andrari et al., 1996). The environmental degradation (seawater and freshwater aquifer) caused the change in hydraulic gradient of aquifer, accelerated the progressive landward invasion of seawater toward the abstraction wells, destructive for the chemical quality, water pollution and surrounding groundwater followed by other

Table 4. The prediction of the distance of seawater intrusion along Jakarta Coast

Year Prediction	Intrusion in Jakarta (km)	
	With mangrove	Without mangrove
1	1.85	8.90
2	2.05	9.25
3	2.24	9.59
4	2.44	9.94
5	2.64	10.29
6	2.84	10.64
7	3.03	10.98
8	3.23	11.33
9	3.43	11.68
10	3.63	12.03

problems such as decrease of freshwater availability, human health and ecosystem damage (Hussain et al., 2015; Howard, 1987; Patel & Shah, 2008).

Basically, the coastal aquifers are very vulnerable toward seawater intrusion because of the overexploitation of the coastal aquifers. Seawater intrusion models are more efficient tools for coastal aquifer management and protection. The disperse interface approach explicitly represents a transition zone or a mixing zone of the freshwater and saltwater within an aquifer due to the effects of hydrodynamic dispersion (Pramada & Mohan, 2015; Park, Kim, Yum, & Yeh, 2012). The instability of freshwater and seawater system in coastal aquifers due to overexploitation produces the landward movement of the seawater wedge. The hydraulic barriers method has the function to reduce seawater invasion with the injection of freshwater and raising aquifer's hydraulic head. The sensitivity of the rate and location to inject water used two laboratory-scale sandboxes under hydraulic confinement to measure the wedge length reduction. The coastal aquifers are principal sources of freshwater in various parts of the world due to their groundwater quantity and quality, suitable to cover water needs of cities, rural villages and agricultural and industrial activities (Acosta & Donado, 2015; Carruthers et al., 2013)

The seawater intrusion prediction with or without mangrove vegetation showed that mangrove ecosystem has an important role in reduction of seawater intrusion in Jakarta. The simulation model also explained the role and function of mangrove to prevent, release and reduce seawater intrusion (Soerianegara, 1987; Hilmi, 1998). The simulation of seawater intrusion model with or without mangrove vegetation used freshwater demand for industry, settlement, community, seawater tide, seawater inundation, rivers' debit, freshwater capacity, topography, rain intensity and mangrove density as elements of this model (Figure 4).

The design of seawater intrusion model used freshwater demand for industry 1,98 m^3t^{-1}, domestic need 4.31 m^3t^{-1}, hotel and settlement 2.11 m^3t^{-1}, seawater tide 0.61 m, seawater level approximately 0.47 m, and domestic freshwater demand in Jakarta approximately 11.3 m^3t^{-1}, topography between -7 m to 10 meter, rain intensity 1750 mm $year^{-1}$, river debit 13.23 m^3dt^{-1} , and mangrove density and mangrove area in seawater Based on seawater mapping it showed that (1) if the width of mangrove greenbelt was 75 m, the distance of seawater intrusion reached 1 km, (2) if the width of mangrove greenbelt was 90 m, the distance of seawater intrusion was approximately 950 m, (3) if the width of mangrove greenbelt 115 m, the distance of seawater intrusion reached 800 m,

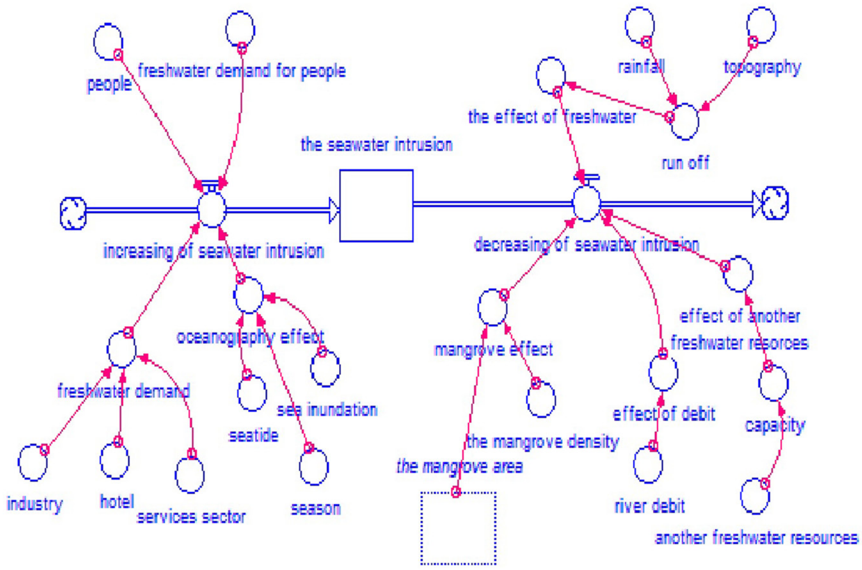
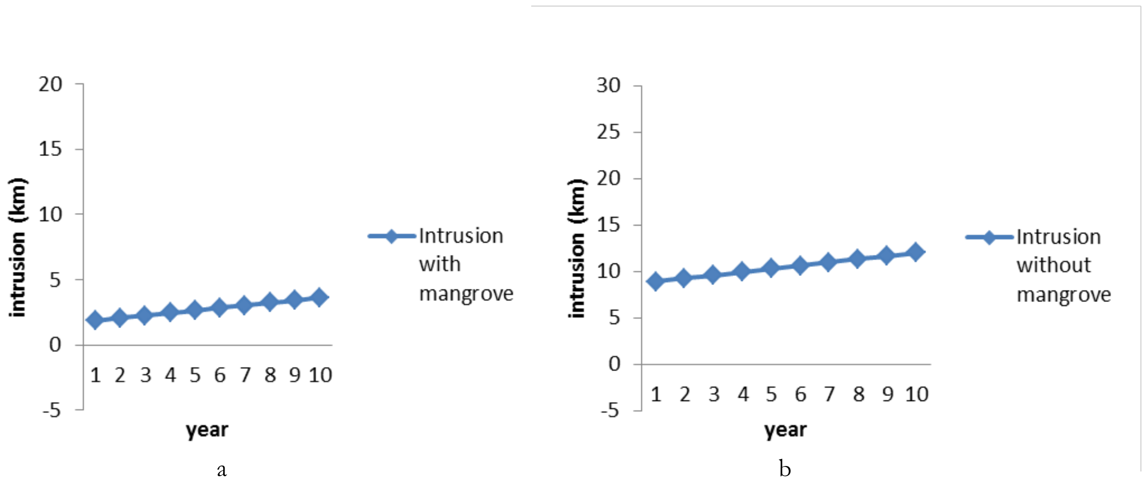


Figure 4. Diagram of modeling seawater intrusion



Remarks : a. The trend in distance of seawater intrusion with mangrove
b. The trend in distance of seawater intrusion without mangrove

Figure 5. The trend of seawater intrusion prediction

(4) if the width of mangrove was more than 115 meter, the distance of seawater intrusion was 500 m - 600 m, and (5) if the width of mangrove < 85 meters, the distance of seawater intrusion reached until 1650 meters.

The simulation model of seawater intrusion shows the combination between freshwater consumption, soil texture, soil pore, soil porosity, topography, (Hilmi, 2003), organic matter (Kairo et al., 2008), density and mangrove zonation (Kairo et al., 2008; Bosire et al., 2005). The simulation model showed that the rate of seawater intrusion is about 0.20 km (with mangrove as a system component), and is about 0.30 – 0.40 km (without mangrove as a system component). The trend of seawater intrusion in Jakarta is not different from seawater intrusion in Semarang which has increased by 0.575 km^2 $years^{-1}$ (Suhartono, Purwanto & Suripin, 2015).

Table 3 also shows that mangrove has an important role to play to reduce the rate of intrusion in Jakarta. Mangrove has ability to reduce seawater intrusion because (1) mangrove vegetations have salt excreation gland, salt accumulation gland, and salt excluder gland (Hamilton & Snedaker, 1984; Hilmi, 2014; Kusmana, 2005; Snedaker & Snedaker, 1984), (2) the decomposition of mangrove litter as the organic matter resource impacts the reduction of the salinity of freshwater. (Bosire et al., 2005), (3) root of mangrove vegetation has ability to prevent seawater penetration to land, (4) the root activity is a mangrove metabolism to recover soil characteristic and dilute salinity of soil water, (5) the extract matter metabolism is mangrove ability to decrease salinity of water (Sigalingging, 1985) and (6) the spesific architecture of mangrove root systems has function to release the negative impact of seawater intrusion (Purnobasuki & Suzuki, 2004).

In Jakarta, the existence of mangrove is a fragile ecosystem because conversion, illegal logging, waste, oil pollution, pesticide pollution, domestic waste, industry waste, etc occures in the mangrove ecosystem. But, mangrove is a resilient ecosystem to live in a wide range of environmental variables (Petrakis et al., 2016), including in freshwater. However, these factors still contribute to have a big impact on the sustainability of mangrove ecosystem in Jakarta. The degradation and mortality of mangrove ecosystem are critical factors (Xiao et al., 2009) that will increase seawater intrusion in Jakarta.

Basically, the ability of mangrove ecosystem to reduce seawater intrusion (Hilmi, 1998; Hilmi et al., 2014) is an important role to keep the sustainability of the ecological function and life supporting system to reduce and prevent seawater entry to land (Hilmi, 1998; Soerianegara, 1987). Seawater intrusion also has correlation with mangrove density which influences the litter degradation process, nutrient demineralization and efficiency of the ecological processes (Bosire et al., 2005). Mangrove also has ability to breakdown organic material in the mangrove ecosystem thus rapidly supporting the recycling of organic matter (Marchand, Allenbach & Lallier-Vergès, 2011; Bosire et al., 2005), increase ability to adsorbent, adsorption and absorption mechanism for organic matter, salinity and other material (Oo et al., 2009), increase supporting the nitrogen process in coastal ecosystem (Kadlec, 2008), reduce water pollution (Narayana et al., 2007) and has high primary productivity. The high productivity is often attributed to high litter degradation rates and efficient recycling of nutrients (Bosire et al., 2005) and finally give effect to release seawater intrusion (Cochard et al., 2008). Based on this reason, mangrove is an important ecosystem as the buffer ecosystem to reduce seawater intrusion (Sigalingging, 1985). Therefore mangrove rehabilitation and area redesign in Jakarta aimed to increase mangrove function to reduce seawater intrusion (Macintosh et al., 2002; Huang et al., 2003) is needed.

D. Effect of Seawater Intrusion on Freshwater Quality

The salinity degree of freshwater was a variable to predict seawater intrusion in the coastal area, and Ca, Mg, Na, Cl and K were used as potential variables to predict the freshwater quality in Jakarta coast. The rate of salinity degree also showed the influence of mangrove ecosystem for prediction of freshwater quality in the seawater intrusion area (Table 5, Figure 6 and 7). This simulation model used mangrove as a main factor to determine the trend of water salinity, because mangrove has secreting, filtering and accumulating processes to reduce water salinity in the coastal area (Hamilton & Snedaker, 1984; Hilmi, 2014; Kusmana, 2005; Snedaker & Snedaker, 1984). The result of this simulation model showed the correlation between mangrove ecosystem with salinity degree of freshwater in the coastal area.

Table 5. Rate of water salinity in Jakarta

Year prediction	Rate of Water Salinity (ppt)
1	1.92
2	2.25
3	2.57
4	2.90
5	3.23
6	3.55
7	3.88
8	4.20
9	4.53
10	4.86

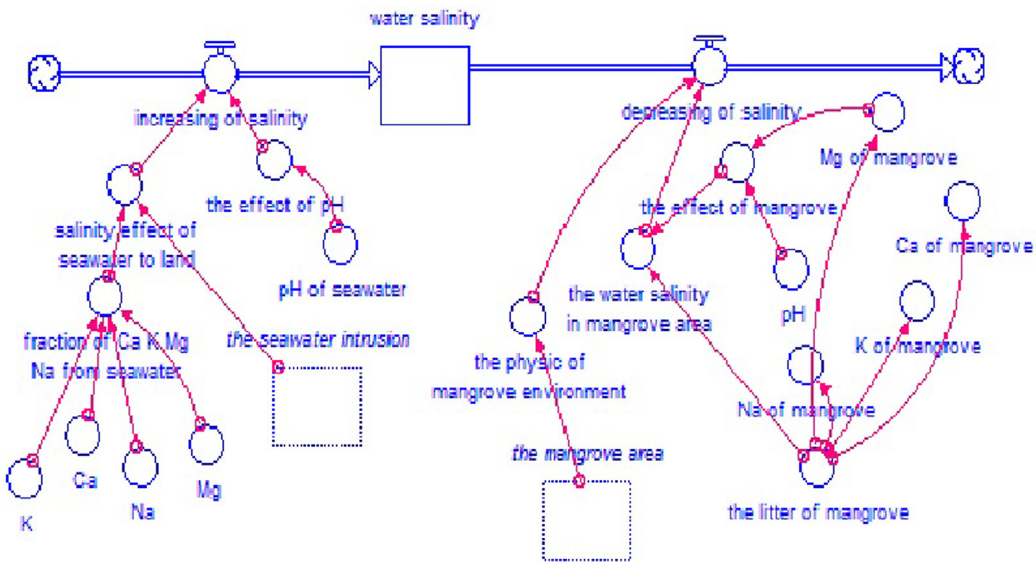


Figure 6. The modeling diagram of water salinity

The result of this simulation model in Figure 7 and Table 5 showed a raising trend of water salinity in Jakarta. The degree of water salinity in Jakarta was predicted between 1.92 ppt (the first year) to 4.86 ppt (year ten). The degree of water salinity was an indicator to analyze sea water intrusion. Todd (1980) noted that seawater intrusion occurred because the quantity of freshwater supply was less than seawater supply causing seawater completely entering into the groundwater as the seawater process in the coastal area.

The rate of seawater intrusion showed an increasing exploitation of freshwater by domestic, hotel, and industry pump. The increasing seawater intrusion caused the high rate of existence and distribution of water salinity in the freshwater ecosystem. The progressive rate of seawater entry to land became a water pollutant for freshwater in Jakarta. The positive trend of seawater intrusion in Jakarta showed significant correlation between mangrove

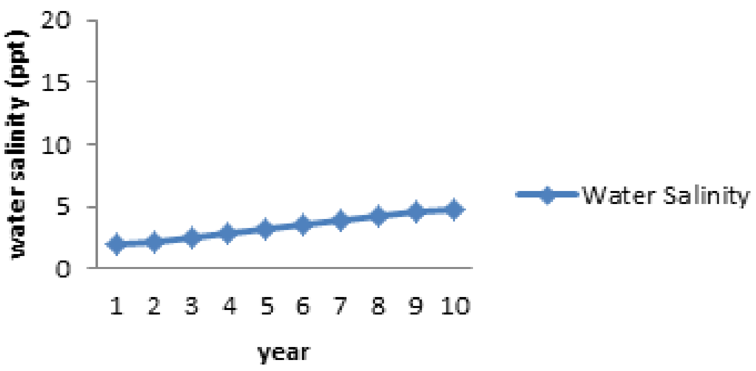


Figure 7. Trend of water salinity in Jakarta

degradation and freshwater demand with seawater intrusion as the significant effect for a destructive barrier line between freshwater and seawater. This condition was a triggering factor for the incidence of seawater intrusion.

E. Equation between Seawater Intrusion and Mangrove Greenbelt

Seawater intrusion and mangrove greenbelt were the variables in the model for estimation of seawater intrusion and the width of mangrove greenbelt. The trend line analysis was used to construct this model (Figure 8). The first equation showed that the distance of seawater intrusion (m) = 2264.9 * exp(-0.009 * the width of mangrove greenbelt (m)) with determination coefficient (R^2) = 94.65 % (Figure 7). The second equation showed that the width of mangrove greenbelt (m) = 781.76 * exp(-0.002 * seawater intrusion (m)) with determination coefficient (R^2) = 62.62 %.

Figure 8 shows that the correlation between seawater intrusion and mangrove width was of a negative exponential model. This model showed that mangrove greenbelt had negative correlation with seawater intrusion. Mangrove greenbelt has the role to reduce seawater intrusion (Hilmi, 2003; Ellison & Farmsworth, 1997; Kairo, Dahdouh-Guebas, Bosire, & Koedam, 2001). This equation also showed that mangrove greenbelt was a main indicator of seawater intrusion in the coastal area. The ability of mangrove ecosystem to reduce seawater intrusion was the linkages with salt excretion, accumulation and exclusion activity. Based on the result of this equation it shows that to release seawater intrusion (the distance = 0 m) there is a need of a mangrove greenbelt approximately of 1.000 m width. and based on the optimal line, Jakarta needs to optimize a mangrove greenbelt of more than 115 m in width.

F. Strategy to Reduce Seawater Intrusion

This strategy aimed to reduce seawater intrusion. The design of mangrove rehabilitation used the following systems:(1) conservation and maintenance of mangrove seedlings, saplings and trees and (2) mangrove species plantation. This design has the purpose to increase mangrove density, biodiversity, ecological function and ecosystem resilience (Macintosh et al., 2002) as a conservation effort of mangrove ecosystem to increase allocation of area to rehabilitate integrated with environmental measures, ecosystem planning and management and complementing the approach of formally protected reserves (Simonsson, Ostlund, & Gustafsson, 2016)

The first stage, to take the best result of mangrove planting, was the selection of mangrove species based on the best ability of mangrove species to reduce seawater intrusion. Mangrove species have different

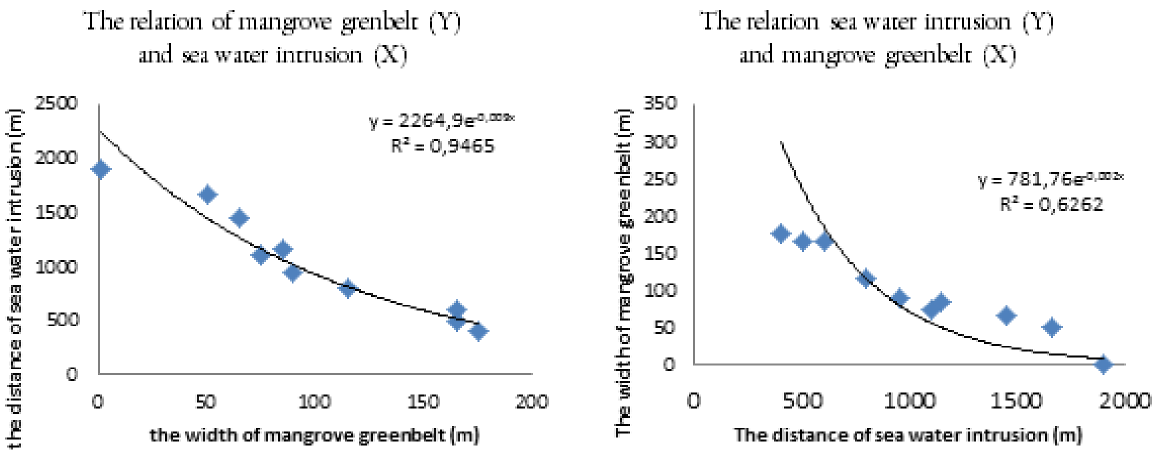


Figure 8. The estimation model for the width of mangrove greenbelt and the distance of seawater intrusion

ability to secrete, accumulate and refuse water salinity. Based on the capacity of water salinity reduction *Avicennia marina*, *Avicennia alba* and *Sonneratia* spp., *Rhizophora apiculata*, *Rhizophora mucronata*, *Bruguiera* spp. are the best suited species for this purpose (Nurmayasri, 1999; Hutchings & Saenger, 1987; Hilmi, 1998). Basically mangrove plantation will construct a mangrove zone aiming to reduce seawater intrusion and to improve habitat changes, water salinity, soil texture and soil fertility (Sandoval-Castro et al., 2012)

Therefore, the priority selection of mangrove species in mangrove zone should use the capacity of salt secretion, accumulation and exclusion gland (Macintosh et al., 2002), mangrove density, growth rate, mangrove root, and another environment factors. The dominant species were (1) grade 1 was *Avicennia marina*, Avicennia alba, *Rhizophora stylosa*, *Sonneratia alba* and *Sonneratia caseolaris*, (2) grade 2 was *Rhizophora apiculata*, *Ceriops* spp., *Rhizophora mucronata*, (3) grade 3 was *Bruguiera gymnorrhiza*, *Bruguiera praviflora*, *Aegiceras* spp., and (4) grade 4 was *Xylocarpus* spp., and *Nypa frutican*.

IV. CONCLUSION

In Jakarta, the existence of mangrove and freshwater demand are the triggering factors for increasing seawater intrusion. The rate of seawater intrusion in Jakarta will reach 0.20 km year^{-1} (with mangrove) is lower than the rate of seawater intrusion approximately 0.3 – 0.4 km year^{-1} (without mangrove). The mangrove degradation reached 1000.05 ha (over 36 years) from 1165.33 ha (1980) to 165.28 ha (2016). The design of mangrove plantation is used to reduce seawater intrusion.

The width of mangrove greenbelt to reduce seawater intrusion is the width of mangrove greenbelt (m) = 781.76* exp(-0.002* seawater intrusion (m)). Based on this equation Jakarta needs a distance of mangrove greenbelt of more than 115 m with species priority of *Avicennia marina*, *Avicennia alba*, *Rhizophora apiculata*, *Rhizophora stylosa*, *Sonneratia alba* and *Sonneratia caseolaris*.

The activity of coastal rehabilitation to reduce seawater intrusion in Jakarta's coastal area is only using the ability of mangrove vegetations and the width of mangrove greenbelt as the main factors. Therefore, the next research should use the mangrove zone as the important factor to reduce high sea waves, seawater flooding and abrasion.

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REFERENCES

Acosta, A.B., & Donado, L.D. (2015). Laboratory scale simulation of hydraulic barriers to seawater intrusion in confined coastal aquifers considering the effects of stratification. 7th Groundwater Symposium of the International Association for Hydro-Environment Engineering and Research (IAHR). *Procedia Environmental Sciences*, *25*, 36 – 43.

Al-Nasrawi, A.K.M., Jones, B.G., Hamilton, S.M., 2016. GIS-based modeling of the vulnerability of coastal wetland ecosystems to environmental changes: Comerong Island, southeastern Australia. *Journal of Coastal Research*, SI (75), 33-37.

Alongi, D.M., Wattayakorn, G., & Boyle S. (2004). Influence of roots and climate on mineral and trace element storage and flux in tropical mangrove soils. *Biogeochemistry*, *69*,105–123.

Andrari, G., Nandang., Masmui., & Priyono. (1996). Algorithmic estimation to minimize seawater intrusion in beach aquifer. B*PP Teknologi magazine*, LXXII. Jakarta.

APHA (American Public Health Association). (2005). *Standard methods for the examination of water and wastewater*. New York.

Badarudeen, A., Damodaran, K.T., Sajan, K., & Padmala, D.L. (1996). Texture and geochemistry of the sediments of a tropical mangrove ecosystem, southwest coast of India. *Environment geology*, *27*, 164–169.

Bengen, D.G. (2002). *Ecosystem and nature resources of coastal and marine and management principles*. Synopsis. PKSPL. Bogor Agriculture Institute, Bogor.

Bengen, D.G., & Dutton, I.M. (2004). Interaction: mangroves, fisheries and forestry management in Indonesia. In T.G. Northcote and Hartman (Eds), Worldwide watershed interaction and management. Blackwell science. Oxford. UK.

Bosire, J.O., Dahdouh-Guebas, F., Kairo, J.G., Kazungu, J., Dehairs, F., & Koedam, N. (2005). Litter degradation and C/N dynamics in reforested mangrove plantations at Gazi Bay, Kenya. *Biological Conservation*, *126*, 287–295.

Cai, F., Su, X., Liu, J., Li, B., & Lei, G. (2009). Coastal erosion in China under the condition of global climate change and measures for its prevention. *Progress in Natural Scienc*e, *19*, 415–426.

Carruthers, T.J.B., Beckert, K., Schupp, C.A., Saxby, T., Kumer, J.P., Thomas, J., Sturgis, B., Dennison, W.C., Williams, M., Fisher, T., & Zimmerman, C.S. (2013). Improving management of a mid-Atlantic Coastal Barrier Island through assessment of habitat condition. *Estuarine, Coastal and Shelf Science*, *116*, 74-86.

Chebo, A.K. (2009). Monitoring wetlands deterioration in the Cameroon coastal lowlands: implications for management. *Procedia Earth and Planetary Science*, *1*, 1010–1015.

Cochard, R., Ranamukhaarachchi, S.L., Shivakoti. G.P., Shipin, O.V., Edwards, P.J., & Seelan, K.T. (2008). The 2004 tsunami in Aceh and Southern Thailand: A review on coastal ecosystems, wave hazards and vulnerability. *Perspectives in Plant Ecology, Evolution and Systematics*, *10*, 3–40

Cochran, W.G. (1997). *Sampling techniques (*3rd edition). John Wiley & Sons.

Ellison, A.M. (2002). Macroecology of mangroves: large-scale patterns and processes in tropical coastal forests. *Trees*, *(2002) 16*, 181–194 . doi:10.1007/s00468-001-0133-7.

Ellison, A.M., & Farmsworth, E.J. (1997). Simulated sea level changes alters anatomy, Physiology, growth, and reproduction of red mangrove (*Rhizophora manglr* L). *Occologia*, *112*, 435 – 446.

Ferreira, T.O., Vidal-Torrado, P., Otero, X.L & Macias, F (2010). Are mangrove forest substrates sediments or soils? A case study in southeastern Brazil. *Catena 70*, 79–91.

Finkl, C.W., (2004). Coastal classification: Systematic approaches to consider in the development of a comprehensive scheme. *Journal of Coastal Research*, *20* (1), 166 – 213.

Hamilton, L.S., & Snedaker, S.C. (1984). *Handbook for mangrove area management*. IUCN Commission on Ecology, Gland.

Hilmi, E. (1998). *Estimation of mangrove greenbelt based on system analysis approach (Case study in Muara Angke Jakarta)*. (Thesis). The Postgraduate Program, IPB. Bogor.

Hilmi, E. (2014). Abrasion reduction based on raising of mangrove ecosystem role as greenbelt. Annual Scientific Meeting of Disaster Research. Surabaya 3 – 5th June 2014

Hilmi, E., Syakti, A.D., & Siregar, A.S. (2014). Conservation strategy for coastal and mangrove ecosystem to reduce tsunami disaster, pollution and ability to sequestrate carbon. *Final Report of Competence Grant*. Universitas of Jenderal Soedirman. Purwokerto.

Howard, K.W.F. (1987). Beneficial aspects of sea-water intrusion. *Ground Water*, *25*(4),398-406.

Huang, L., Tan, Y., Song, X., Huang, X., Wang, H., Zhang, S., Dong. J., & Chen, R. (2003). The status of the ecological environment and a proposed protection strategy in Sanya Bay, Hainan Island, China. *Marine Pollution Bulletin*, *47*, 180–186.

Hussain, M.S., Javadi, A.A., & Sherif, M.M. (2015). Three dimensional simulation of seawater intrusion in a regional coastal aquifer in UAE. 13th Computer Control for Water Industry Conference, CCWI 2015. *Procedia Engineering*, *119*, 1153 – 1160

Hutchings, P., &. Saenger, P. (1987). *Ecology of mangrove*. New York: University of Queensland Press.

Kadlec, R.H. (2008). The effects of wetland vegetation and morphology on nitrogen processing. *Ecological Engineering*, *33*, 126-141.

Kairo, J.G., Dahdouh-Guebas, F., Bosire, J., & Koedam, N. (2001). Restoration and management of mangrove systems - a lesson for and from the East African region. *South African Journal of Botany*, *67*, 383–389.

Kairo, J.G., Lang'at, J.K.S., Dahdouh-Guebas, F., Bosire, J., & Karachi, M. (2008). Structural development and productivity of replanted mangrove plantations in Kenya. *Forest Ecology and Management*, *255*, 2670–2677.

Kathiresan, K., & Bingham, B.L. (2001). Biology of mangroves and mangrove ecosystems. *Adv Mar Biology*, *40*, 238–251.

Kathiresan, K., & Rajendran, N. (2005). Coastal mangrove forest mitigated tsunami. *Estuarine, Coastal and Shelf Science*, *65*, 601-606.

Krauss, K.W., Lovelock, C.E., McKee, K.L., Hoffman, L., Ewe. S.M.L., & Sousa, W.P. (2008). Environmental drivers in mangrove establishment and early development: A review. *Aquatic Botany*, *89*, 105–127.

Kusmana, C. (1997). *Vegetation survey metho*d. Bogor: IPB Press.

Kusmana, C. (2005). *Mangrove ecology*. Ecology Laboratory in Forest Faculty IPB, Bogor. P: 150.

Lopes, G.P., Bouillon, S., Mangion, P., Macia, A., & Paula J., (2009). Population structure, density and food sources of T*erebralia palustris* (Potamididae: Gastropoda) in a low intertidal *Avicennia marina* mangrove stand (Inhaca Island, Mozambique). *Estuarine, Coastal and Shelf Science*, *84*, 318–325.

Lunstrum, A., & Chen, L. (2014). Soil carbon stocks and accumulation in young mangrove forests. *Soil Biology & Biochemistry*, *75*, 223-232.

Machado, W., Moscatelli, M., & Rezende, L.G. (2002). Mercury, zinc, and copper accumulation in mangrove sediments surrounding a large landfill in southeast Brazil. *Environment Pollution*, *120*, 455-461.

Macintosh, D.J., Ashton, E.C., & Havanon, S. (2002). Mangrove rehabilitation and intertidal biodiversity: A study in the Ranong Mangrove Ecosystem, Thailand. *Estuarine, Coastal and Shelf Science*, *55*, 331–345.

Marchand, C., Allenbach, M., & Lallier-Vergès, E. (2011). Relationships between heavy metals distribution and organic matter cycling in mangrove sediments (Conception Bay, New Caledonia). *Geoderma*, *160*, 444 – 456.

Massel, S.R., Furukawa, K., & Brinkman, R.M. (1999). Surface wave propagation in mangrove forest. *Fluid Dynamic Research Elsevier Science*, *24*, 219 – 249.

Mazda, Y., Kanazawa, N., & Wolanski, E. (1995).

Tidal asymetry in mangrove creeks. *Hydrobiologia*, *295*, 51 – 58.

Morgan, L.K., & Wernera, A.D. (2015). A national inventory of seawater intrusion vulnerability for Australia. *Journal of Hydrology: Regional Studies*, *4*, 686–698.

Muhdin., Suhendang, E., Wahjono, D., Purnomo, H., Istomo., Simanungsong, B.C.H. (2011). The estimation model of Stand Structure Dynamics for Logged-over Natural Forests. *Journal of Tropical Forest Management, 17*(1), 1-9.

Nagelkerken, I., Blaber, S.J.M., Bouillon, S., Green, P., Haywood, M., Kirton, L.G., Meynecke, J.O., Pawlik, J., Penrose, H.M., Sasekumar, A., & Somerfield, P.J. (2008) The habitat function of mangroves for terrestrial and marine fauna: A review. *Aquatic Botany*, *89*, 155–185.

Narayan, K.A., Schleeberger, C., & Bristow, K.L. (2007). Modelling seawater intrusion in the Burdekin Delta Irrigation Area, North Queensland, Australia. *Agricultural Water Management*, *89*(3), 217-228.

Narayana, A.C., Tatavarti, R., Shinu, N., & Subeer, A. (2007). Tsunami of December 26, 2004 on the southwest coast of India: Post-tsunami geomorphic and sediment characteristics. *Marine Geology*, *242*, 155–168.

Nurmayasri, T.W. (1999). The growth ability of mangrove trees of *Avicennia marina*, *Bruguiera gymnorrhiza*, and *Rhizophora mucronata* for salinity level. Bandung: Winayamukti University.

Oo, C.W., Kassima, M.J., & Pizzi, A. (2009). Characterization and performance of *Rhizophora apiculata* mangrove polyflavonoid tannins in the adsorption of copper (II) and lead (II). *Industrial Crops and Products*, *30*, 152–161

Paris, R., Wassmer, P., Sartohadi, J., Lavigne, L., Barthomeuf, B., Desgages, E., Grancher, D., Baumert, P., Vautier, F., Brunstein, D., & Gomez, C. (2009). Tsunamis as geomorphic crises: Lessons from the December 26th, 2004 tsunami in Lhok Nga, West Banda Aceh (Sumatra, Indonesia). *Geomorphology*, *104*, 59–72

Park, S., Kim, J., Yum, B., & Yeh, G. (2012). Three-dimensional numerical simulation of saltwater extraction schemes to mitigate seawater intrusion due to groundwater pumping in a coastal aquifer system. *Journal of Hydrologic Engineering*, *17*(1), 10–22.

Parvaresh, H., Abedi, Z., Farshchi, P., Karami, M., Khorasani, N., & Karbassi, A. (2011). Bioavailability and concentration of heavy metals in the sediments and leaves of grey mangrove, *Avicennia marina* (Forsk.) Vierh, in Sirik Azini Creek, Iran. *Biological Trace Element Research*, *143* (2), 1121–1130. doi:10.1007/s12011-010-8891-y

Patel, A.S., & Shah, D.L. (2008). W*ater management: Conservation, harvesting and artificial recharge*. New age international (p) limited, publishers.

Petrakis, R., Wu, Z., McVay, J., Middleton, B., Dye, D & Vogel, J (2016). Vegetative response to water availability on the San Carlos Apache Reservation. *Forest Ecology and Management*. *378,* 14-23.

Pirzan, A.M., Gunarto, R., Daud., & Burhanuddin. (2004). The relation of soil organic matter, soil texture with macrobenthos diversity in fishpond and mangrove. *Jurnal Penelitian Perikanan Indonesia*, *10* (20), 27 – 34.

Prahasta, E. (2008). *Remote sensing*. Bandung: Informatika.

Pramada, S.K., & Mohan, S. (2015). Stochastic simulation of seawater intrusion into freshwater aquifers. International Conference on Tropical and Coastal Region Eco-Development 2014 (ICTCRED 2014). *Aquatic Procedia*, *4*, 87-94.

Purnobasuki, H & Suzuki, M (2004). Root system architecture and gravity perception of a mangrove plant, *Sonneratia alba* J. Smith. *Journal of Plant Biology*, *47*(3), 236-243.

Purwadhi, S. H. (2001). *Satellite imagery interpretation*. Jakarta: PT. Grasindo.

Robins,P.E., Skov, M.W., Lewis, M.J., Gimenez, L., Davies, A.G., Malham, S.K., Neill, S.P., McDonald, J.E., Whitton, T.A., Jackson , S.E & Jago, C.F (2016). Impact of climate change on UK estuaries: A review of past trends and potential projections. *Estuarine, Coastal and Shelf Science*. *169*, 119-135.

Salampessy, M.L., Febryano, I.G., Martin, E., Siahaya, M.E., & Papilaya, R. (2015). Cultural capital of the communities in the mangrove conservation in the coastal areas of Ambon Dalam Bay, Moluccas, Indonesia. (2015) International Conference on Tropical and Coastal Region Eco-Development 2014 (ICTCRED 2014). *Procedia Environmental Sciences*, *23*, 222 – 229.

Sandoval-Castro, E., Mu˜niz-Salazar, R., Enríquez-Paredes, L.M., Riosmena-Rodríguez, R., Dodd, R.S., Tovilla-Hernández, C., & Arredondo-García, M.C. (2012). Genetic population structure of red mangrove (R*hizophora mangle* L.) along the Northwestern Coast of Mexico. *Aquatic Botany*, *99*, 20– 26.

Sigalingging, M. (1985). *Land use and soil reclamation in seawater intrusion area in North Indramayu*. (Thesis). The Postgraduate Program IPB, Bogor.

Simonsson, P., Ostlund, L &Gustafsson, L (2016). Conservation values of certified-driven voluntary forest set-asides. *Forest Ecology and Management, 375*, 249–258.

Snedaker, S.C., & Snedaker, J.G. (1984). *The mangrove ecosystem : research methods*. UNESCO

Soerianegara, I. (1987). The widht of mangrove green belt as coastal zone protection forest. *Media Konservasi*, *1*(4), 21-30.

Soil Research Department of Agriculture Ministry. (2005). *The analysis of soil chemical, plant, water and fertilizer*. Jakarta.

Steel, R.G.D & Torrie, J.H. (1980). *Principles and procedures of statistics (A biometrical approach).* (2nd edition). New York: McGraw - Hill.

Suhartono, E., Purwanto, P., & Suripin, S. (2015). Seawater intrusion modeling on groundwater confined aquifer in Semarang. International Conference on Tropical and Coastal Region Eco-Development 2014 (ICTCRED 2014). *Procedia Environmental Sciences*, *23*, 110 – 115.

Todd, D.K. (1980). *Groundwater hydrology* (2nd editons). New York-Chichester-Brisbane-Toronto-Singapore: John Wiley & Sons.

Wang, Y., Qiu, Q., Xin, G., Yang, Z., Zheng, J., Ye Z., & Li, S. (2013). Heavy metal contamination in a vulnerable mangrove swamp in South China. *Environment Monitoring Assesment. 185* (7), 5775–5787. doi:10.1007/s10661-012-2983-4.

Xiao, Y., Jie, Z., Wang, M., Lin, G.I., & Wang, W. (2009). Leaf and stem anatomical responses to periodical waterlogging in simulated tidalfloods in mangrove *Avicennia marina* seedlings. *Aquatic Botany*, *91*, 231–237.

Xiao, Y., Wang, W., & Chen, L. (2010). Stem anatomical variations in seedlings of the mangrove *Bruguiera gymnorrhiza* grown under periodical waterlogging. *Flora*, *205*, 499–505.

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<u>Reference List</u>

American Society for Testing and Materials (ASTM). (1997). *Standard test methods for rubber products—Chemical analysis*. (ASTM-D297-93)American Society for Testing of Materials, USA.

Ayuk, E.T., Duguma, B., Franzel, S., Kengue, J., & Zenkeng, P. (1999). Uses, management and economic potential of *Irvingia gabonensis* in the humid lowlands of Cameroon. *Forest Ecology and Management*, *113*, 1-19.

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Kementerian Kehutanan. (2009). *Keputusan Menteri Kehutanan No.SK/328/Menhut-II/2009 tentang Penetapan DAS Prioritas dalam rangka RPJM tahun 2010-2014*. Sekretariat Jenderal, Jakarta.

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Kurinobu, S. & Rimbawanto, A. (2002). Genetic improvement of plantation species in Indonesia. In A. Rimbawanto, & M. Susanto (Eds.), *Proceeding of International Conference on advances in genetic improvement of tropical tree species,* 1-3 October 2002 (pp.1-6). Yogyakarta: Centre for Forest Biotechnology and Tree Improvement.

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Water is a necessary part of every reasons's diet and of all the nutrient a body needs to function, it requires more water each daya than any other nutrients a body needs to function, it requires more water each day than any other nutrient (Whitney & Rolfes, 2011)

Or

Whitney and Rolfes (2011) state the body requires many nutrients to function but highlight that water is of greater importance than any other nutrient.

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Kata kunci: Empat sampai enam kata kunci untuk keperluan indeksasi dan abstraksi. Setiap kata mencakup isu yang dibahas dan diurutkan secara alphabet dipisahkan oleh tanda koma

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ACKNOWLEDGEMENT

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REFERENCES

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REFERENCE LIST

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Society for Testing of Materials, USA.

Ayuk, E.T., Duguma, B., Franzel, S., Kengue, J., & Zenkeng, P. (1999). Uses, management and economic potential of Irvingia gabonensis in the humid lowlands of Cameroon. *Forest Ecology and Management*, *113*, 1-19.

Chen, H.Q., Wei, J.H., Yang, J.L., Ziang, Z., Yang, Y., Gao, J.-H., … Gong, B. (2012). Review : Chemical constituens of agarwood originating from the endemic genus Aquilaria plants. *Chemistry and Biodiversity*, *9*, 236–250.

Kementerian Kehutanan. (2009). *Keputusan Menteri Kehutanan No.SK/328/Menhut-II/2009 tentang Penetapan DAS Prioritas dalam rangka RPJM tahun 2010-2014*. Sekretariat Jenderal, Jakarta.

Kenney, G.M., Cook, A., & Pelletier, J. (2009). Prospects for reducing uninsured rates among children: How much can premium assistance programs help. Retrieved from Urban Institute website: http://www.urban.org/url.cfm?ID=411823, at 1 October 2009.

Kurinobu, S. & Rimbawanto, A. (2002). Genetic improvement of plantation species in Indonesia. In A. Rimbawanto, & M. Susanto (Eds.), *Proceeding of International Conference on advances in genetic improvement of tropical tree species*, 1-3 October 2002 (pp.1-6). Yogyakarta: Centre for Forest Biotechnology and Tree Improvement.

Lee, S.S. (2003). Pathology of tropical hardwood plantation in South-East Asia. *New Zealand Journal of Forestry Science*, *33*(3), 321-335.

Lim, S.C. (1998). Barringtonia J.R. Forster, & J.G. Forster. In M.S.M. Sosef, L.T. Hong, & S. Prawirohatmodjo (Eds.), *Plant Resources of South-East Asia 5*(3): *Timber trees: Lesser-known timbers*. (pp. 98-102). Leiden: Backhuys Publishers.

Matsuo, M., Yokoyama, M., Umemura, K., Sugiyama, J., Kawai, S., Gril, J., …Imamura, M. (2011). Aging of wood: Analysis of color changes during natural aging and heat treatment. *Holzforschung*, *65*, 361-368.

Pallardy, S.G. (2008). *Physiology of woody plants* (4th ed.). London: Elsevier Inc.

Raghavendra, A.S. (1991). *Physiology of trees*. USA: John Willey and Sons Inc.

Salampessy, F. (2009). Strategi dan teknik pemasaran gaharu di Indonesia. Paper presented at Workshop pengembangan teknologi produksi gaharu berbasis pada pemberdayaan masyarakat di sekitar hutan, Bogor 29 April 2009.

Thuo, A.D.M. (2013). Qualitive analysis of land use change pressures, conditions, and drivers in rural-urban fringes: A case of Nairobi rural-urban fringe, Kenya. *International Journal of Innovation and Applied Studies*, *3*, 820–828.

Wezel, A., Rajot, J.L., & Herbrig, C. (2000). Influence of shrubs on soil characteristics and their function in Sahelian agro-ecosystems in semi-arid Niger. *Journal of Arid Environment*, *44*, 383-398. doi:10.1006/jare.1999.0609.

Wohl, E., Dwire, K., Sutfin, N., Polvi, L., & Bazan, R. (2012). Mechanism of carbon storage in mountainous headwater rivers. *Nature Communications*, *3*, 1263. doi:10.1028/ncommc2274.

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