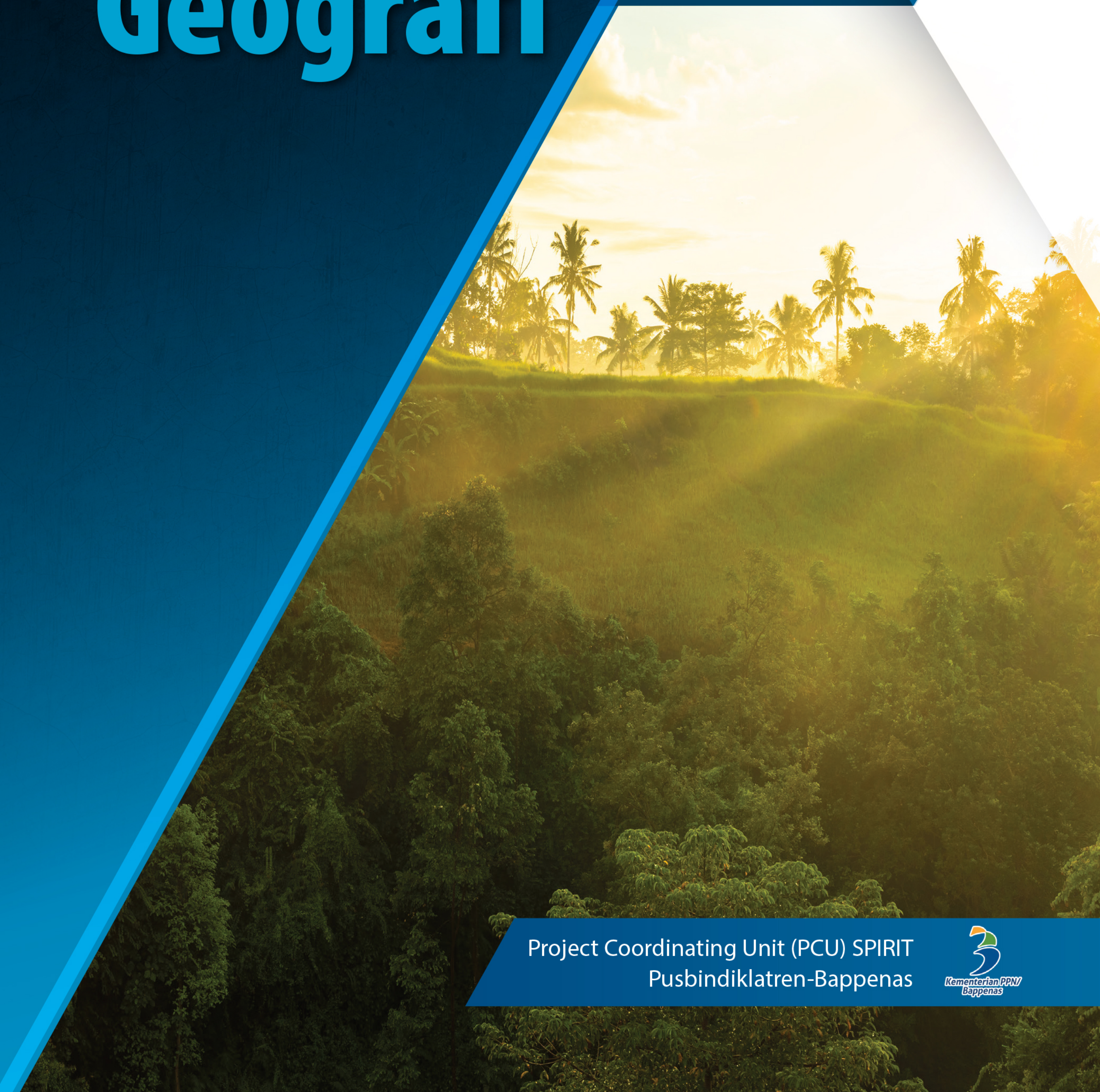
Bunga Rampai Tesis/Disertasi

SPIRIT

Scholarship Program for Strengthening Reforming Institutions

Tema:

Geografi



Project Coordinating Unit (PCU) SPIRIT
Pusbindiklatren-Bappenas

Kementerian PPN/ Bappenas

Bunga Rampai Tesis/Disertasi

TEMA: GEOGRAFI

Program Beasiswa SPIRIT

Editor:

Dr. Nur Hygiawati Rahayu, ST, M.Sc, dkk.

Project Coordinating Unit (PCU) SPIRIT
Pusbindiklatren-Bappenas

Kementerian PPN/
Bappenas

Bunga Rampai Tesis/Disertasi
Tema: Geografi Kelompok Ilmu Alam dan Interdisiplin

Editor
Dr. Nur Hygiawati Rahayu, ST, M.Sc.
Wignyo Adiyoso, S.Sos, MA, Ph.D.
Ali Muharam, SIP, MSE, MA.
Rita Miranda, S.Sos, MPA.
Wiky Witarni, S.Sos, MA.

Kontributor
Arief Prasetyo, Cahya Budi Perwitagama, Diah Dzihrina, Diana wisnu Wardani, Eri Khaeruman Khuluki, Frans Janporta Sitepu, Lia Fitriasari Rahayu, Marthalina Indahwati, Mas Bambang Agus Wijaya, Nina Windialika, Rizky Agung Nugroho, Septina Marryanti P, Siti Hamim Latifah, Sukmo Pinuji, Tatag Bagus Narendra, Valentina Ingradiarini, Wahyu Nugroho

Cetakan I, November 2017
ISBN: 978-602-1154-94-6

Diterbitkan oleh
Project Coordinating Unit (PCU) SPIRIT, Pusbindiklatren
Badan Perencanaan Pembangunan Nasional (Bappenas) Republik Indonesia
Jalan Proklamasi Nomor 70 Jakarta Pusat 10320

KATA PENGANTAR

Prioritas utama target pembangunan nasional seperti yang tertuang dalam Rencana Pembangunan Jangka Menengah Nasional Tahun 2010–2014 (RPJMN 2010–2014) Indonesia adalah reformasi birokrasi dan penguatan tata laksana pemerintahan. Untuk mencapai hal ini, sebelas institusi pemerintah yang memiliki peran penting dalam sektor publik dipilih sebagai Participating Agency (PA) dalam program beasiswa SPIRIT (Scholarship Program for Strengthening Reforming Institutions). SPIRIT dirancang untuk mendukung agenda reformasi birokrasi dengan menyediakan program beasiswa gelar dan nongelar untuk staf kunci di institusi publik pusat selama periode tahun 2011–2017.

Tujuan pelaksanaan program SPIRIT adalah untuk meningkatkan kapasitas Participating Agency melalui 1) peningkatan kapasitas sumber daya manusia (SDM) dengan mengembangkan keterampilan teknis, manajerial, dan kepemimpinan aparat pemerintah yang melaksanakan tugas-tugas pokok dan fungsi institusi; dan 2) peningkatan kapasitas SDM dalam melaksanakan reformasi birokrasi di instansi pusat.

Perancangan program SPIRIT dibedakan dengan program beasiswa lainnya di Indonesia melalui upaya pemenuhan kesenjangan kompetensi dan keahlian di tiap-tiap instansi dengan menanamkan program pendidikan gelar dan nongelar dalam Human Capital Development Plans (HCDP) di tiap-tiap instansi secara eksplisit. Program SPIRIT didukung melalui kerja sama antara pemerintah Indonesia dan Bank Dunia (World Bank) melalui pinjaman IBRD Loan No. 8010-ID.

Buku *Bunga Rampai Tesis/Disertasi Program Beasiswa SPIRIT, Tema: Geografi* ini merupakan buku kedelapan dari sembilan buku yang akan diterbitkan pada tahun 2017, sebagai salah satu upaya mendiseminasikan karya tulis ilmiah yang telah diselesaikan oleh karyasiswa penerima beasiswa SPIRIT. Materi tesis/disertasi dibagi menjadi tiga kelompok, yaitu Ilmu-Ilmu Ekonomi, Ilmu-Ilmu Sosial, dan Ilmu-Ilmu Alam dan Interdisiplin. Dasar pembagiannya adalah disiplin keilmuan (*tree of science*) serta keseimbangan jumlah materi tesis/disertasi yang ada.

Tujuan dari penerbitan serial buku ini, pertama, menyebarluaskan hasil-hasil penelitian tesis/disertasi, agar dapat direplikasi atau diadopsi di tempat kerja karyasiswa; kedua, sebagai *benchmark* pemanfaatannya di instansi pemerintah lain; dan ketiga, merupakan bagian dari upaya mendokumentasikan kegiatan SPIRIT, dalam bentuk terbitan ilmiah buku ber-ISBN sehingga dapat disebutkan oleh karyasiswa dalam resume masing-masing. Versi cetak serial buku ini dapat di akses secara *online* www.pusbindiklatren.bappenas.go.id

Serial buku ini diharapkan dapat menggambarkan manfaat dan kontribusi positif Program SPIRIT terhadap peningkatan kapasitas SDM sebagai *participating agencies*, baik dari sisi keterampilan teknis, manajerial, dan kepemimpinan aparat pemerintah, dan dalam melaksanakan reformasi birokrasi di instansi masing-masing. Program SPIRIT juga diharapkan dapat berkontribusi bagi pencapaian sasaran prioritas nasional dalam meningkatkan kinerja instansi pemerintah yang ditandai dengan berkurangnya praktik korupsi, kolusi, dan nepotisme, serta meningkatnya kualitas pelayanan publik.

Jakarta, November 2017

Pusbindiklatren Bappenas

DAFTAR ISI

Bunga Rampai Tesis/Disertasi

GEOGRAFI

Program Beasiswa SPIRIT

Pola Spasial Penjalaran Perkotaan Bodetabek

Urban Sprawl Spatial Pattern of Bodetabek

Nama	: Arief Prasetyo
NIP	: 198111262009031002
Instansi	: BPN
Tahun Intake	: 2017
Tingkat Beasiswa	: Master Local
Program Studi	: Magister Ilmu Geografi
Negara Studi	: Indonesia
Universitas	: Universitas Indonesia

ABSTRAK

Perkembangan perkotaan yang pesat terjadi di negara berkembang terutama pada wilayah pinggiran kota. Dampaknya adalah terjadinya penjalaran yang merupakan fenomena perkotaan yang kompleks dan sulit diukur. Pemangku kebijakan memerlukan metode yang sederhana untuk mengontrol dan mengevaluasi penjalaran sebuah kota. Penelitian ini bertujuan untuk mengukur dan menilai tingkat penjalaran perkotaan menggunakan model *Shannon Entropy* dengan mempertimbangkan jarak terhadap pusat kota dan jaringan jalan. Penerapan *Shannon's Entropy* di Bodetabek pada 1989-2014 menunjukkan bahwa pola penjalaran linier lebih dominan terjadi di Kabupaten Bogor, Bekasi dan Kota Bogor. Semakin besarnya indeks *Shannon's Entropy* mengindikasikan keenderungan penjalaran perkotaan yang semakin acak. Pola penjalaran melompat (acak) terjadi di Kabupaten Tangerang yang ditandai indeks entropy yang tinggi. Penjalaran kota di Bodetabek dipengaruhi oleh karakterik fisik dan sosial wilayah terutama aspek kemiringan tanah dan perubahan jumlah penduduk.

Kata Kunci : Penjalaran, Bodetabek, Penginderaan Jauh, *Shannon's Entropy*

ABSTRACT

Rapid urban development occurred in developing countries, particularly in the urban fringe area. The impact was related to the occurrence of urban sprawl which is highly complex urban phenomenon and difficult to measure. Related stakeholders require a simple method to estimate and evaluate the urban sprawl patterns. This paper aims to measure and asses the level of urban sprawl based on Shannon's Entropy considering on two aspect i.e. the distance to town center and road networks. Application of Shannon's Entropy in Bodetabek for 1989-2014 described that linear pattern of sprawling mostly happened in Bogor, Bekasi and Bogor city. With increasing of entropy index, this pattern tends to become more scattered in the future, even in Bogor regency the pattern becomes leapfrog characteristics for 2014. Tangerang Regency showed leapfrog pattern with high entropy index. Urban sprawl in Bodetabek driven by region's physical and social characteristics mainly with slope and population growth.

Keywords: Sprawl, Bodetabek, Remote Sensing, Shannon's Entropy.

Secara demografis, penyebab pertambahan penduduk perkotaan adalah pertambahan penduduk alamiah, yaitu jumlah orang yang lahir dikurangi jumlah orang yang meninggal; migrasi penduduk khususnya dari wilayah rural ke wilayah urban; serta reklasifikasi yaitu perubahan status 'desa' (lokalitas), dari 'lokalitas rural' menjadi 'lokalitas urban' sesuai dengan kriteria yang ditetapkan dalam Sensus oleh BPS. Pertambahan penduduk alamiah menyumbang sepertiga bagian sedangkan migrasi dan reklasifikasi memberikan andil duapertiga pada kenaikan jumlah penduduk perkotaan di Indonesia. Sehingga migrasi dan reklasifikasi merupakan faktor utama dari pertambahan penduduk perkotaan di Indonesia (Firman dan Soegijoko, 2005). Wilayah pinggiran harus menyediakan lahan untuk menampung penduduk yang "terdesak" keluar DKI Jakarta. Hal tersebut menyebabkan tumbuhnya wilayah terbangun yang kebanyakan didominasi oleh hunian yang menyebabkan terjadinya penjalaran perkotaan yang tidak terkendali.

Penjalaran perkotaan ditinjau berbagai aspek, baik dari aspek fisik, lingkungan, demografi, budaya maupun ekonomi. Sulit untuk mendapatkan definisi yang tepat tentang penjalaran kota. Kompleksitas penjalaran menyebabkan sulit untuk mengukur penjalaran kota dengan baik. Perkembangan wilayah terbangun merupakan salah satu indikator yang paling mudah untuk bisa mengenali terjadi penjalaran.

Pemahaman tentang perkembangan dan perubahan pola wilayah terbangun menjadi perhatian utama bagi pemerintah dan stakeholder yang berkepentingan terhadap perencanaan kota. Hal tersebut mengakibatkan kebutuhan data spasial yang diperlukan untuk mengevaluasi gejala perkotaan yang tengah berlangsung dan juga perubahan pola wilayah terbangun menjadi kebutuhan utama. Data spasial wilayah terbangun dapat diperoleh dengan memanfaatkan teknologi Penginderaan Jauh dan Sistem Informasi Geografis (SIG).

Pemanfaatan teknologi Penginderaan Jauh untuk kajian perkotaan sudah banyak diaplikasikan pada berbagai skala. Penginderaan jauh merupakan teknologi yang sesuai untuk diaplikasikan untuk berbagai studi perkotaan (Donnay, dkk, 2001). Aplikasi penginderaan jauh perkotaan mampu diaplikasikan untuk menyajikan berbagai data spasial mengenai morfologi kota, pola penggunaan lahan, infrastruktur, distribusi populasi dan berbagai faktor pendorong terjadinya perkembanga kota (Bhatta, 2010). Kemampuan penginderaan jauh menyajikan data spasial perkotaan menjadikan teknologi ini sudah lazim digunakan untuk studi perkotaan. Gejala penjalaran fisik kota yang bersifat spasial dan temporal juga sangat mudah untuk bisa dikaji dengan memanfaatkan data satelit yang didapatkan dari teknologi penginderaan jauh yang diintegrasikan dengan Sistem Informasi Geografi. Kajian penjalaran fisik kota bisa dikaji dari aspek luas pertambahan wilayah terbangun dan juga pola spasialnya.

Penelitian ini melakukan kajian pola spasial penjalaran perkotaan di Bodetabek dengan menggunakan data penginderaan jauh sebagai data primer. Penjalaran diukur secara kuantitatif dengan pendekatan *Shannon's Entropy* untuk mengevaluasi tingkat penjalaran secara kuantitatif dan polanya secara spasial. Penelitian ini melibatkan fisik dan sosial wilayah sebagai variabel penelitian untuk melihat keterkaitan aspek tersebut terhadap meningkatnya wilayah terbangun pada wilayah kajian. Masing-masing wilayah memiliki karakterfisik fisik dan sosial yang berbeda-beda, sehingga akan memiliki respon yang berbeda-beda terhadap fenomena penjalaran fisik kota (*urban sprawl)*.

Penjalaran perkotaan merupakan gejala yang dapat dilihat dari beberapa aspek seperti aspek fisik, sosial maupun ekonomi. Aspek sosial kependudukan di wilayah Bodetabek menunjukkan peningkatan jumlah penduduk di Bodetabek yang signifikan pada 1980-2010, sedangkan pada periode yang sama pertambahan penduduk di DKI Jakarta cenderung konstan dan memiliki pertumbuhan yang lebih rendah. Gejala ini menunjukkan adanya penjalaran perkotaan di Bodetabek dari aspek kependudukan, yang dapat dirasakan dengan semakin padatnya penduduk di Bodetabek. Hal tersebut menjadi masalah tersendiri bagi pengambil keputusan, dalam hal ini pemerintah, dimana fenomena ini dapat dirasakan namun tidak dapat mengetahui seberapa ukuran dan arahnya (Frankel dan Ashkenazi, 2008).

Penelitian mengenai penjalaran dari aspek ekonomi pernah dilakukan oleh Harmadi dan Yudhistira (2008) dengan mengidentifikasi peran ekonomi sektoral terkait dengan perubahan penggunaan tanah sebagai identifikasi penjalaran kota menggunakan metode statistik. Hasil penelitian menunjukkan adanya pengaruh kegiatan ekonomi terhadap penjalaran kota, namun tidak bisa menjelaskan proses penjalaran kota secara spasial dan seberapa besar kekuatannya. Penjalaran yang kuat akan membutuhkan lahan yang semakin besar (Bogue, 1956). Fakta ini mendorong dikembangkannya indikator *Land Resource Impact* (LRI) oleh Hasse dan Lathrop (2003) untuk melihat fenomena penjalaran kota. Beberapa penelitian diatas dapat mendeteksi terjadinya penjalaran namun dirasa masih tidak cukup baik untuk mengetahui seberapa jauh tingkat penjalaran kota yang terjadi pada sebuah wilayah. Gejala penjalaran hanya disajikan dalam bentuk angka dan tabel sehingga informasi yang disajikan tidak lengkap terutama dalam paparan keruangan (spasial).

Claude Shannon (1948) merumuskan sebuah persamaan untuk mengukur derajat ketidakteratutan yang dikenal dengan Shannon's Entropy dengan mengadopsi hukum kedua termodinamika. Ahli geografi mengimplementasikan pendekatan tersebut untuk mengukur ketidakteraturan gejala perkotaan, seperti wilayah terbangun sebagai gejala indikator penjalaran. Kajian spasial penjalaran perkotaan dengan metode tersebut mampu memberikan perbandingan kekuatan dan pola penjalaran serta perubahannya secara temporal pada beberapa wilayah dengan dinamika wilayah yang tinggi seperti Bodetabek. Berangkat dari uraian tersebut, berikut ini dirangkum pertanyaan penelitian sebagai berikut:

1. Bagaimana pola penjalaran kota yang diukur menggunakan *Shannon's Entropy* di wilayah Bodetabek
2. Bagaimana keterkaitan faktor fisik dan sosial wilayah terhadap penjalaran perkotaan Bodetabek?

Tujuan utama penelitian adalah menganalisis kecenderungan pola spasial penjalaran perkotaan di wilayah Bodetabek secara kuantitatif dan kualitatif. Secara umum penelitian ini bermanfaat bagi para pemangku kepentingan seperti pemerintah dan para perencana sebagai pedoman untuk mengendalikan penjalaran kota. Secara khusus penelitian ini dapat bermanfaat untuk dapat diaplikasikan di wilayah lain yang mempunyai tingkat sensitifitas penjalaran kota yang tinggi

Penutup Lahan Bodetabek

Analisis tutupan lahan Bodetabek dilakukan dengan menggunakan data spasial yang diekstrak dari data penginderaan jauh yaitu citra Landsat. Sebelum data tersebut dapat digunakan harus dilakukan uji ketelitian untuk mengukur akurasi interpretasi yang telah dilaksanakan. Uji ketelitian harus memenuhi standar kriteria tertentu untuk dapat digunakan untuk analisis selanjutnya.

Perkembangan wilayah terbangun ke Selatan banyak terjadi di Kota Depok. Pemekaran Kota Depok mengakibatkan munculnya berbagai proyek perumahan maupun kawasan perniagaan sehingga pada periode ini terjadi peningkatan luasan wilayah terbangun secara signifikan. Kabupaten Bogor juga mengalami perkembangan wilayah terbangun terutama di sekitar Cibinong sebagai ibukota. Wilayah terbangun juga nampak semakin menjamur di Kecamatan Gunung Putri yang berdekatan dengan kawasan industri.

Perkembangan wilayah terbangun Bodetabek 1989-2014 tidak terlepas dari aspek alami wilayah seperti karakteristik fisik wilayah. Hasil penelitian menjelaskan perkembangan wilayah terbangun pada wilayah yang datar seperti Kabupaten Tangerang dan Bekasi lebih cepat jika dibandingkan wilayah yang memiliki topografi yang beragam yaitu Kabupaten Bogor. Kabupaten Tangerang dan Bekasi mempunyai satuan bentuklahan berupa dataran aluvial pantai dan kipas aluvial dengan relief yang halus. Kondisi tersebut sangat memungkinkan pembangunan hunian atau perumahan dan berbagai sarana dan prasarana pendukungnya.

Karakteristik Bogor lebih kompleks dengan bentuk lahan berupa pedataran kipas aluvium, perbukitan lipatan, kaki gunung api bergelombang, dan kerucut gunung api. Satuan bentuklahan yang kompleks menyebabkan perkembangan wilayah terbangun lebih lambat jika dibandingkan wilayah Barat dan Timur Bodetabek. Perkembangan wilayah terbangun di selatan Bodetabek dimulai pada bentuk lahan pedataran kipas aluivium yang meliputi Kota Depok dan Kota Bogor. Sedangkan wilayah yang lain lebih lambat. Perkembangan wilayah terbangun di satuan bentuk lahan perbukitan lebih sulit jika dibandingkan dataran dan memerlukan biaya yang mahal.

Berdasarkan uraian tersebut, selain faktor fisik dan sosial wilayah, penjalaran perkotaan sangat dipengaruhi oleh berbagai kebijakan yang diterapkan pemerintah. Gambaran perkembangan wilayah terbangun tersebut menggambarkan penjalaran kota secara spasial, namun demikian penggambaran ini masih belum mampu untuk menjelaskan ukuran penjalaran yang terjadi dan bagaimana pola yang terjadi.

Nilai Indeks Shannon's Entropy Bodetabek

Penilaian indeks Shannon's entropy dititikberatkan untuk mengetahui penjalaran di Bodetabek pada tahun 1989, 2000 dan 2014. Penghitungan dilakukan menggunakan dua perspektif yaitu jarak terhadap pusat kota (H'p) dan jaringan jalan (H'j). Nilai-nilai tersebut dijadikan dasar untuk menentukan tipe penjalaran perkotaan di Bodetabek. Analisis menggunakan kombinasi dari analisis indeks *Shannon's entropy* yang kemudian dikonversi menjadi indeks *relative entropy,* analisis matriks keruangan *relative entropy,* dan analisis pola spasial penjalaran berdasarkan nilai entropy menggunakan grid 1 x 1 km sebagai spasial unit (*grid wise).*

Penjalaran juga terjadi pada wilayah yang berbatasan dengan DKI Jakarta yaitu pada beberapa kecamatan yang mengalami perluasan wilayah terbangun dengan nilai entropy tinggi seperti di Kecamatan Pondok Gede, Bekasi Timur, Bekasi Selatan, Bekasi Utara, Medan Satria, Tambun Selatan dan Rawa Lumbu. Sama halnya dengan penjalaran fisik kota di Cikarang, penjalaran fisik kota di wilayah yang berbatasan dengan Jakarta dominan ke arah Selatan dibandingkan Utara. Sama halnya dengan periode sebelumnya, wilayah terbangun dengan kepadatan yang lebih rendah berada disekitar wilayah terbangun dengan kepadatan tinggi secara gradual. Hal ini menunjukkan bahwa pertumbuhan wilayah terbangun juga mengikuti pola wilayah terbangun yang telah ada.

Secara umum penjalaran perkotaan Kabupaten Bekasi dominan mengarah ke Selatan dibandingkan Utara. Hal ini wajar mengingat pada masa lampau Bekasi merupakan lumbung padi bagi wilayah Jakarta, sehingga keberadaan lahan pertanian di Bekasi bagian Utara tetap dipertahankan sebagai lahan pertanian. Hal ini juga tercermin dalam dokumen Rencana Tata Ruang Jabodetabek-Punjur dalam Peraturan Presiden Nomor 54 tahun 2008 dimana sebagian wilayah Kabupaten Bekasi bagian Utara diperuntukkan sebagai lahan pertanian lahan basah.

Penjalaran perkotaan Bodetabek secara keseluruhan dapat dikatakan masih bersifat linier terhadap jalan. Pada periode 1980-1990, sistem transportasi massal masih dianggap sesuatu yang mahal, sehingga pembangunan yang dilakukan oleh pemerintah dan pengembang di Bodetabek memilih lokasi yang berdekatan dengan jalan utama yang telah dibangun oleh Presiden Soekarno pada tahun 1960-an (Rustiadi dkk, 2015). Hal tersebut terkait dengan kemudahan transportasi ke tempat bekerja. Penduduk yang bertempat tinggal di wilayah Bodetabek umumnya bekerja di kota Jakarta sehingga mereka membutuhkan akses yang mudah untuk dapat sampai ke tempat mereka bekerja.

Kebijakan relokasi industri yang diambil pemerintah dengan mengalihkan kegiatan industri ke Barat dan Timur Bodetabek berdampak signifikan terhadap penjalaran dimana wilayah Barat dan Timur mengalami penjalaran kota yang lebih cepat dibandingkan Selatan. Hal ini tidak terlepas dari konsep *people follow jobs,* dimana terjadinya perpindahan lokasi sektor manufaktur (industri) akan menyebabkan penduduk yang ingin bekerja di sektor tersebut memilih tinggal di wilayah sekitarnya, sehingga terjadilah perambatan/penjalaran hunian (Yudhistira dan Harmadi, 2008).

Hubungan Karakter Fisik dan Sosial Wilayah

Analisis hubungan karakteristik fisik dan sosial wilayah terhadap penjalaran kota menggunakan analisis statistik. Analisis statistik yang digunakan memperhatikan jenis data yang dilibatkan. Dalam penelitian ini dilakukan dua jenis uji statistik yaitu regresi logistik biner untuk data berbasiskan raster dan analisis regresi linier untuk data tabular.

Faktor fisik yang sangat berpengaruh terhadap adalah faktor kemiringan tanah dan ketinggian, dimana faktor kemiringan tanah mempunyai probabilitas yang tinggi untuk terjadi penjalaran perkotaan ketika kemiringan tanah cukup datar. Aspek sosial yang berpengaruh adalah keberadaan CBD, dimana semakin dekat dengan CBD maka probablitas untuk terjadi penjalaran kota cukup besar yaitu 90,91 kali. Sedangkan aspek jarak terhadap jalan juga memiliki pengaruh terhadap penjalaran walaupun dengan pengaruh yang lebih kecil. Faktor demografi juga memberikan dampak yang besar terhadap penjalaran, dimana pertambahan penduduk berpengaruh positif dan memberikan distribusi sebesar 30,6 % terhadap penjalaran perkotaan.

Nampak adanya keterkaitan antara penjalaran perkotaan yang direpresentasikan dengan perkembangan wilayah terbangun dengan aspek fisik dan sosial wilayah. Aspek fisik berupa kemiringan tanah dan ketinggian tempat mempunyai pengaruh yang signifikan. Hal ini dapat dilihat dari hasil nilai probabilitas yang dihasilkan dari uji regresi logistik. Perkembangan wilayah terbangun pada wilayah yang datar lebih mudah dan menguntungkan karena tidak memerlukan biaya yang relatif besar jika dibandingkan membangun pada wilayah dengan kemiringan yang curam. Walaupun memang lambat laun perkembangan wilayah terbangun pada kemiringan yang tidak datar (bervariasi) akan terjadi dan menimbulkan pola penjalaran perkotaan yang melompat (*leapfog development)* yang dicirikan munculnya bangunan dengan kepadatan rendah secara acak. Gejala tersebut terjadi di Kabupaten Bogor pada tahun 2014. Aspek demografi juga sangat terkait dengan penjalaran perkotaan dimana kebutuhan akan hunian menjadi sesuatu yang mutlak untuk dipenuhi dengan terus bertambahnya jumlah penduduk. Akibatnya adalah meluasnya wilayah terbangun sebagai ciri terjadinya penjalaran perkotaan.

Kesimpulan

Berdasarkan hasil penghitungan indeks r*elative entropy* yang telah dilakukan dan hasil analisis yang telah dibahas dalam bab sebelumnya, maka kesimpulan dari penelitian ini adalah sebagai berikut :

1. Penjalaran perkotaan di Bodetabek didominasi tipe penjalaran linier atau *ribbon development* yang dapat dijumpai di Bogor, Bekasi dan Kota Bogor. Kecenderungan pola yang terjadi adalah pola penjalaran semakin acak/tidak teratur dan berpotensi menjadi pola melompat (*leapfrog)* seiring dengan bertambahnya nilai relative entropy, baik terhadap jalan maupun terhadap pusat kota. Bahkan pola penjalaran Kabupaten Bogor sudah berubah pada 2014 menjadi pola melompat (*leapfrog).*
2. Pola penjalaran acak atau *leapfrog development* terjadi di Kabupaten Tangerang dimana sejak periode awal ditandai dengan tingginya nilai relative entropy baik terhadap pusat kota maupun jaringan jalan.
3. Berdasarkan uji regresi logistik, faktor kemiringan tanah merupakan faktor yang paling berpengaruh terhadap perubahan wilayah non terbangun menjadi wilayah terbangun, sehingga faktor ini merupakan faktor dominan terhadap penjalaran perkotaan Bodetabek.
4. Faktor jumlah penduduk mempunyai keterkaitan dan berpengaruh positif terhadap perkembangan wilayah non terbangun menjadi terbangun sehingga pertambahan penduduk merupakan faktor yang relatif dominan terhadap penjalaran perkotaan Bodetabek.

Metode Non-Parametrik Classification Tree Analysis (CTA) dengan Teknik Data Mining untuk Klasifikasi Penggunaan Lahan Menggunakan Citra Landsat-8 Oli

Non-Parametric Methods Classification Tree Analysis (CTA) with Data Mining Techniques for Land Use Classification Using Landsat-8 Oli Imagery

Nama	: Cahya Budi Perwitagama
NIP	: 198204182008041003
Instansi	: BPN
Tahun Intake	: 2012
Tingkat Beasiswa	: Master Local
Program Studi	: Pengindraan Jauh
Negara Studi	: Indonesia
Universitas	: Universitas Gadjah Mada

ABSTRAK

Kajian mengenai metode *non-parametrik Classification Tree Analysis* (CTA) menggunakan teknik data mining untuk aplikasi penginderaan jauh masih belum banyak dilakukan. Sehingga diperlukan penelitian mengenai kemampuan CTA dalam menangani data yang cukup banyak, dengan memanfaatkan kelebihan CTA untuk aplikasi penginderaan jauh. Kombinasi parameter CTA dan data masukan, serta penerapannya pada dua skema klasifikasi yang berbeda tingkat kerinciannya, memerlukan pengujian terkait dengan tingkat akurasi yang dihasilkan. Penelitian ini bertujuan melakukan simulasi dari beberapa kombinasi parameter untuk mengetahui tingkat akurasi hasil klasifikasi, dan memperoleh pohon keputusan dari hasil KDD. Serta menganalisis akurasi metode non-parametrik CTA dengan teknik data mining untuk klasifikasi penggunaan lahan menggunakan citra Landsat-8 OLI, dan menerapkan hasil KDD pada daerah lain.
Klasifikasi diperoleh dengan melakukan simulasi beberapa parameter CTA dan data masukan. Parameter aturan pemisah (splitting rules) dalam CTA, yaitu Ratio, Entropy, dan Gini. Parameter pemangkas (pruning), yaitu 0%, 1%, 5%, dan 10%. Beberapa masukan data klasifikasi, antara lain adalah citra Landsat-8 tujuh saluran, transformasi citra (NDVI, NDWI, BI, NDBI, dan PCA), serta filter tekstur *variance* dan mean (jendela bergerak 3x3 dan 5x5). Data non-spektral, yaitu data ketinggian dan data kemiringan lereng. Dua tingkat skema klasifikasi penggunaan lahan, yaitu Level I (5 kelas) dan Level II (8 kelas). Pohon keputusan yang diperoleh dari hasil pembelajaran dengan akurasi terbaik kemudian diterapkan pada daerah lain yang memiliki karakteristik mirip.
Hasil penelitian menunjukkan bahwa kombinasi parameter terbaik adalah atribut pemisah Gini, pruning 1%, filter tekstur dengan jendela bergerak 5x5, dan skema Level I yaitu dengan akurasi keseluruhan 96,71%, kappa 0,9504, dan waktu proses 3,388 detik. Penerapannya pada daerah lain, menghasilkan akurasi keseluruhan 93,27% dengan kappa 0,8923. Tingkat akurasi terbaik yang diperoleh pada daerah penelitian maupun penerapannya pada daerah lain, lebih besar dari 90%. Sehingga diharapkan metode ini dapat menjadi alternatif metode untuk terapan kebijakan penggunaan lahan, dan klasifikasi penggunaan lahan berbasis penutup lahan setara dengan skala 1:100.000.

Kata Kunci: *Classification Tree Analysis* (CTA), *data mining*, klasifikasi penggunaan lahan, Landsat-8

ABSTRACT

The study of non-parametric methods Classification Tree Analysis (CTA) using data mining techniques for remote sensing applications is still much to do, so it require studies on the CTA's ability to handle quite a lot of data, by utilizing CTA advantages for remote sensing applications. The combination of parameter CTA and data input, as well as its application on two different detail levels of land use classification scheme, require testing related to the level of accuracy that is generated. This studies aimed to simulate multiple combinations of parameters to determine the level of accuracy of the classification results, and obtain a decision tree from KDD results. And to analyze the accuracy of non-parametric methods CTA with data mining techniques for land use classification using Landsat-8 OLI, and apply the results of KDD on another area.

The classification is obtained by performing simulations on several parameters CTA and data input. There are three splitting rules parameter in CTA, i.e. Ratio, Entropy, and Gini. Pruning parameter, i.e. 0%, 1%, 5%, and 10%. There are several inputs of the classification data, namely seven bands of Landsat-8 OLI imagery, image transformation (NDVI, NDWI, BI, NDBI, and PCA), as well as texture filter variance and texture filter mean (moving window 3x3 and 5x5). Non-spectral data, i.e.elevation data and slope data. And two-level land use classification scheme, i.e. Level I (5 classes) and Level II (8 classes). The decision tree that obtained from the best accuracy of the learning outcomes then applied to another area with similar characteristics.

The results showed that the best parameter combination are a splitting attribute Gini, pruning 1%, texture filter with 5x5 moving window,and Level I scheme, with an accuracy of 96.71%, kappa 0.9504, and processing time 3.388 sec. Its aplication on another area, resulting an overall accuracy 93.27% with kappa 0.8923. The best accuracy rate obtained in this study and its application on another area was greater than 90%. Therefore this method is expected could be an alternative method for land use policy application, and land use classification based on land cover commensurate to a scale of 1:100,000.

Keywords: Classification Tree Analysis (CTA), data mining, land use classification, Landsat-8

Satelit Landsat merupakan satelit milik Amerika Serikat yang pertama kali diluncurkan adalah Landsat-1, pada tanggal 23 Juli 1972. Landsat yang telah berkembang hingga terkini adalah Landsat-8, diluncurkan pada tanggal 11 Februari 2013, dengan sensor *Operational Land Imager* (OLI) dan *Thermal Infrared Senso*r (TIRS). Sensor OLI terdiri atas 9 (sembilan) saluran dengan resolusi spasial 30 meter untuk citra multispektral dan pankromatik dengan resolusi spasial 15 meter, sedangkan TIRS terdiri atas 2 (dua) saluran dengan resolusi spasial 100 meter untuk citra inframerah termal. Landsat-8 memiliki ukuran scene 170 km x 185 km dengan perencanaan beroperasi minimal selama lima tahun.

Dengan adanya penemuan teknologi satelit, metode untuk memperoleh informasi detil permukaan lahan termasuk penggunaan dan penutup lahan menjadi lebih efisien dalam hal biaya dan waktu pemrosesannya serta penerapan prosedur yang sistematik dibandingkan pengukuran langsung di lapangan yang dilakukan sebelumnya (Wheatley et al., 2000 dalam Indrawati, 2009). Perkembangan teknologi penginderaan jauh ini diiringi dengan perkembangan pengolahan citra digital. Semakin meningkatnya kemampuan komputer dalam mengolah proses yang cukup besar, sangat membantu dalam pengembangan berbagai teknik dan analisis citra digital. Pengolahan citra digital ini salah satunya adalah dapat dimanfaatkan untuk klasifikasi.

Klasifikasi multispektral pada umumnya menghasilkan peta penutup lahan. Penutup lahan dapat diinterpretasi menggunakan citra penginderaan jauh. Dari data dan informasi tersebut dapat diturunkan menjadi informasi-informasi lain, seperti penggunaan lahan. Agar dapat digunakan untuk memperoleh informasi penggunaan lahan, diperlukan tambahan data pendukung lain. Dalam algoritma klasifikasi multispektral pada umumnya dibagi menjadi dua, yaitu algoritma parametrik dan algoritma non-parametrik.

Algoritma parametrik mengasumsikan bahwa kelas terdistribusi normal dan memerlukan perkiraan distribusi parameter, seperti *mean vector* dan *covariance matrix* dalam melakukan klasifikasi. Algoritma parametrik yang umumnya digunakan dalam melakukan klasifikasi multispektral adalah maximum likelihood dan minimum distance. Algoritma non-parametrik menggunakan asumsi distribusi bebas, menjadi keunggulannya yang akan lebih baik digunakan pada distribusi kelas dengan variabilitas yang lebar. Terdapat beberapa algoritma non-parametrik, antara lain adalah jaringan syaraf tiruan (JST), pohon keputusan, logika *fuzzy*, dan *support vector machine* (SVM).

Data-data penginderaan jauh dan Sistem Informasi Geografis (SIG) saat ini telah banyak dijumpai. Sehingga diperlukan suatu metode yang dapat memanfaatkan data-data tersebut untuk memperoleh informasi baru. Teknik data mining (*Knowledge Discovery from Data*/KDD) banyak digunakan dalam mengolah data-data yang cukup banyak untuk memperoleh informasi baru yang bermanfaat. Salah satu metode dalam KDD untuk mengekstraksi informasi adalah menggunakan metode *machine learning*.

CTA merupakan algoritma *machine learning* yang dapat digunakan mengklasifikasi data penginderaan jauh dan data pendukungnya. Meskipun kadang disebut sebagai *decision tree* (pohon keputusan), namun lebih cenderung sebagai jenis pohon keputusan yang mengarah ke keputusan kategoris. Suatu *classification tree* (pohon klasifikasi) terdiri atas "cabang-cabang" yang mewakili 'atribut', sedangkan "daun" mewakili 'keputusan'. Proses pengambilan keputusan dimulai pada "batang" dan mengikuti "cabang" sampai mencapai "daun" (Clark Labs, 2008). Dalam Wu dan Kumar (2009) algoritma C4.5 dan CART termasuk sepuluh algoritma teratas yang paling berpengaruh dan banyak digunakan dalam data mining, dengan algoritma C4.5 urutan pertama dan algoritma CART urutan kesepuluh. Hal ini diungkapkan dalam komunitas data mining pada konferensi Institute of Electrical and Electronics Engineers (IEEE) International Conference in Data Mining (ICDM) di tahun 2006. Dimana dua algoritma tersebut termasuk dalam algoritma CTA, yaitu gain *ratio* dan *gini index*.

Informasi penggunaan lahan merupakan hal penting, informasi tersebut dapat digunakan untuk perencanaan, pengelolaan dan pemantauan perubahan lingkungan, sehingga sumber daya alam yang ada dapat dimanfaatkan optimal dan berkelanjutan. Penginderaan jauh dapat digunakan untuk mengekstraksi informasi penutup dan penggunaan lahan, selain menggunakan survei terestris. Dengan menggunakan teknologi penginderaan jauh untuk memperoleh informasi penutup dan penggunaan lahan, maka penggunaan sumber daya manusia, waktu, dan biaya dapat lebih ditekan.

Skema klasifikasi penggunaan lahan dalam penelitian ini akan mengacu skema klasifikasi penggunaan tanah dari Badan Pertanahan Nasional Republik Indonesia (BPN-RI) Tahun 2012. Dalam skema klasifikasi penggunaan lahan penelitian ini diperlukan modifikasi dengan menggunakan kelas-kelas yang berbasis penutup lahan. Hal ini dikarenakan pada sistem klasifikasi BPN-RI dipengaruhi oleh metode terestris sehingga tidak semua informasi penggunaan lahan dapat diperoleh menggunakan metode penginderaan jauh. Dalam penelitian ini akan menggunakan dua level skema klasifikasi, yaitu Level I terdiri atas 5 (lima) kelas berbasis penutup lahan dimodifikasi dari skema klasifikasi BPN-RI skala 1:100.000, dan Level II terdiri atas 8 (delapan) kelas berbasis penutup lahan dimodifikasi dari skema klasifikasi BPN-RI skala 1:50.000 yang masih dapat diinterpretasi dari citra Landsat-8 OLI.

Saat ini terdapat berbagai macam data penginderaan jauh maupun data Sistem Informasi Geografis (SIG) dan semakin berjalannya waktu data-data tersebut akan semakin berkembang. Data-data tersebut dapat dimanfaatkan untuk memperoleh informasi penggunaan lahan, sedangkan kemampuan manusia untuk menganalisis data dalam jumlah banyak terbatas, maka diperlukan suatu metode yang dapat membantu dalam melakukan analisis. Hal ini dapat dilakukan dengan menggunakan teknik data mining, melalui masukan data yang cukup banyak, kemudian "ditambang" untuk memperoleh informasi baru yang bermanfaat.

Machine learning merupakan salah satu metode dalam data mining atau KDD untuk mengekstraksi informasi. CTA merupakan metode machine learning yang dapat digunakan dengan beberapa kelebihannya untuk melakukan klasifikasi penggunaan lahan. Metode non-parametrik CTA memiliki beberapa parameter, antara lain aturan pemisah (*splitting rules)*: *ratio, entropy*, dan *gini,* serta parameter pemangkas *(prunning*): *auto-prunning*. Dari parameter-parameter CTA tersebut belum diketahui kombinasi parameter paling tepat yang akan memberikan tingkat akurasi terbaik dalam mengekstraksi informasi penggunaan lahan. Permasalahan penelitian dapat dirumuskan sebagai berikut:

1. Semakin banyaknya data seiring dengan berjalannya waktu diperlukan metode untuk membantu menganalisis data-data tersebut menjadi informasi baru yang bermanfaat, dalam hal ini informasi penggunaan lahan. Menggunakan teknik data mining atau KDD dalam mengekstraksi informasi penggunaan lahan dari data-data yang ada, dengan cara memanfaatkan CTA sebagai metode machine learning pada KDD. Pemilihan aturan pemisah dan pemangkas metode CTA, kombinasi parameter-parameter data masukan dari citra Landsat-8 OLI serta data non-spektral, dan penerapannya pada dua skema klasifikasi penggunaan lahan dari modifikasi skema BPN berbasis penutup lahan yang berbeda tingkat kerinciannya, memerlukan pengujian terkait dengan tingkat akurasi hasil klasifikasi penggunaan lahan yang dihasilkan.
2. Pemanfaatan data citra penginderaan jauh dan pendukungnya menggunakan metode non-parametrik CTA dengan teknik data mining untuk klasifikasi penggunaan lahan berbasis penutup lahan dengan dua level klasifikasi perlu dilakukan penelitian untuk mengetahui apakah memenuhi kriteria akurasi yang disyaratkan dalam klasifikasi penggunaan lahan.

Tujuan dari penelitian ini adalah untuk melakukan simulasi dari beberapa kombinasi parameter data masukan, parameter CTA, dan parameter skema klasifikasi untuk mengetahui tingkat akurasi hasil klasifikasi penggunaan lahan menggunakan metode CTA dengan teknik data mining memanfaatkan citra Landsat-8 OLI. Serta memperoleh pohon keputusan dari hasil KDD.

Analisis Pengaruh Parameter terhadap Hasil Klasifikasi

Pencatatan waktu dalam penelitian ini menggunakan *stopwatch,* bukan tercatat langsung dari sistem perangkat lunak CTA. Sehingga akan terdapat selisih waktu beberapa mili-detik, berkaitan dengan respon peneliti ketika mengamati proses dengan penghentian *stopwatch.* Dari 48 simulasi tersebut dapat diketahui bahwa atribut pemisah *Gain Ratio (Ratio)* memiliki waktu klasifikasi lebih lama dibandingkan dengan *Entropy (Information Gain)*. Hal ini dikarenakan algoritma *Ratio* merupakan proses tambahan dari algoritma *Entropy.*

Proses algoritma CTA pada umumnya tergolong cepat dengan hanya memerlukan waktu terlama eksekusi 29.81 detik untuk mengolah 34 data masukan dengan 8 kelas penggunaan lahan serta tanpa ada pemotongan pohon keputusan, dan menggunakan *algoritma Ratio*. Dengan rata-rata waktu eksekusi simulasi selama 7 detik. Walaupun demikian yang perlu diperhatikan adalah perangkat keras dalam pemrosesan juga mempengaruhi waktu proses, dimana penelitian ini menggunakan Intel Core i5 2,5 GHz dengan RAM 4GB.

Dengan semakin berkembangnya teknologi komputer saat ini maka penerapan metode CTA dengan masukan data yang cukup banyak dalam hal ini 34 data *raster* masukan dengan ukuran 700x700 piksel tidak akan membutuhkan waktu yang lama jika dieksekusi menggunakan perangkat keras terkini. Waktu proses yang cepat ini memang termasuk keunggulan dari metode CTA, yaitu efisiensi komputasi.

Akurasi pada skema klasifikasi Level I yang terdiri atas 5 kelas memiliki akurasi lebih tinggi dibandingkan dengan skema Level II yang terdiri atas 8 kelas dengan kelas lebih rinci. Filter tekstur Mean dan Variance dengan jendela bergerak 5x5 memiliki akurasi lebih tinggi dibandingkan filter tekstur dengan jendela bergerak 3x3 pada skema klasifikasi yang sama di setiap parameter pruning.

Parameter Entropy dengan akurasi tertinggi adalah pruning dengan 1%, skema klasifikasi penggunaan lahan level I, dan filter tekstur 5x5, yaitu dengan akurasi 96,3% kappa 0,944 (CTA16). Untuk skema klasifikasi penggunaan lahan Level II, kombinasi parameter Entropy tertinggi adalah prunning dengan 1% dan filter tekstur 5x5, dengan akurasi 94,92% kappa 0,9404 (CTA40).

Hasil klasifikasi penggunaan lahan dengan parameter atribut pemisah *Gini Index*. Skema klasifikasi Level I pada umumnya memiliki akurasi lebih tinggi dibandingkan skema Level II, kecuali pada parameter pruning 0% dengan filter tekstur 5x5. Pada atribut pemisah *Gini,* kombinasi parameter terbaik adalah pruning 1%, *filter* tekstur dengan jendela bergerak 5x5, dan skema klasifikasi Level I, yaitu dengan akurasi 96,71% dan kappa 0,9504 (CTA18). Untuk skema klasifikasi penggunaan lahan Level II kombinasi parameter terbaik adalah pruning 1% dan filter tekstur 5x5, dengan nilai akurasi 95,75% dan kappa 0,95 (CTA42).

Simulasi penelitian dengan berbagai parameter telah menghasilkan akurasi klasifikasi terbaik dengan nilai akurasi 96,71% dan nilai *kappa* 0,9504, pada simulasi CTA18. Kombinasi parameter terbaik tersebut adalah split type: *Gini, pruning:* 1%, *filter teksture* 5x5, dan skema klasifikasi penggunaan lahan Level I. Untuk skema klasifikasi penggunaan lahan Level II, akurasi terbaik pada simulasi CTA42 dengan nilai akurasi 95,75% dan nilai kappa 0,95, kombinasi parameter simulasi tersebut adalah split type: *Gini, pruning:* 1%, *filter teksture* 5x5.

Analisis Hasil Klasifikasi Penggunaan Lahan Terbaik

Hasil klasifikasi penggunaan lahan dengan akurasi terbaik dalam penelitian ini diperoleh simulasi CTA18 dengan 5 kelas penggunaan lahan (skema Level I). *Pixels* merupakan jumlah piksel dalam daun. Nilai persen merupakan persentase dari piksel yang termasuk dalam total piksel pada kelas tersebut. *Purity index* pada pohon keputusan tersebut adalah persentase piksel yang benar milik kelas tertentu dalam daun dari total jumlah piksel dalam daun. Rincian daun ini dihitung dari data training. Kompleksitas pohon biasanya diukur dengan salah satu dari beberapa hal berikut: jumlah node, jumlah *leaf, tree depth* (kedalaman pohon) dan jumlah atribut yang digunakan. Jumlah *node* pada pohon keputusan klasifikasi terbaik skema level I adalah 22. Jumlah *leaf* adalah 22, kedalaman pohon keputusan adalah 8. Dari pohon keputusan tersebut paling sederhana adalah dalam menentukan kelas Tanah Industri (Ti) atau berupa "*Class* 2" hanya memerlukan 2 *node,* yaitu *Band* 34 (*Filter Tekstur Varian* 5x5 Band 7) dan *Band* 28 (*Filter Tekstur Varian* 5x5 *Band* 1). Sedangkan yang memerlukan banyak node dalam memisahkan kelas Tanah Pertanian dan Hutan.

Jumlah *node* pada pohon keputusan klasifikasi terbaik skema level II adalah 33. Jumlah *leaf* adalah 34, kedalaman pohon keputusan adalah 7. Dari pohon keputusan klasifikasi terbaik skema level II yang paling sederhana adalah dalam menentukan kelas Tanah Industri (Ti) atau berupa "*Class* 3" dimana hanya memerlukan 3 *node*, yaitu *Band 7, Band 24* dan *Band 28.* Sedangkan yang memerlukan banyak node adalah dalam memisahkan kelas Tegalan (*Class* 5) dengan kelas yang lainnya.

Dari kedua pohon keputusan di atas dapat diketahui bahwa untuk menentukan kelas penggunaan lahan skema Level I memerlukan 14 saluran data masukan dari 34 data masukan yang diberikan. Sedangkan untuk menentukan kelas penggunaan lahan skema Level II memerlukan 17 saluran data masukan atau separuh dari 34 data masukan yang diberikan dalam penelitian. Hal ini dikarenakan, menurut analisis dari CTA bahwa data-data yang tidak digunakan tersebut dianggap tidak konsisten, sehingga tidak dapat digunakan untuk memisahkan antar kelas penggunaan lahan.

Proses penentuan kelas pada pohon keputusan ternyata berhubungan dengan indeks separabilitas dari daerah contoh. Dapat dilihat dari kelas tanah industri yang memiliki indeks keterpisahan cukup baik dengan kelas-kelas yang lain sehingga dalam menentukannya tidak memerlukan *node* yang banyak. Sedangkan pada kelas tegalan dan kelas kebun campuran atau tanah pertanian pada skema level I, dimana memiliki keterpisahan yang kurang baik, memerlukan banyak node untuk memisahkannya dengan kelas-kelas yang lainnya.

Klasifikasi penggunaan lahan dengan skema penggunaan lahan level I memperoleh akurasi terbaik diperoleh dari kombinasi parameter, yaitu parameter pemisah *Gini*, *pruning* 1%, dan tekstur jendela bergerak 5x5, untuk mengetahui penilaian akurasi digunakan matriks kesalahan.

Akurasi keseluruhan (*overall accuracy)* dapat dihitung dari hasil bagi antara jumlah keseluruhan piksel yang terklasifikasi secara benar dengan jumlah keseluruhan piksel referensi. Akurasi penghasil diperoleh dari hasil bagi jumlah piksel yang terklasifikasi secara benar untuk setiap kategori dengan jumlah piksel pada tiap training set. Akurasi menurut pengguna dihitung dengan cara membagi jumlah piksel yang terklasifikasi secara benar di tiap kategori dengan jumlah keseluruhan piksel yang diklasifikasi pada kategori tersebut (Danoedoro, 2012).

Besar akurasi keseluruhan (*overall accuracy*) pada hasil klasifikasi dengan skema penggunaan lahan level I diperoleh sebesar 96,71% dan kappa 0,9504. Kesalahan penghilangan/omisi (*ommision)* tertinggi pada kelas Perairan Darat (Pd) sebesar 11,43%, dan kesalahan penambahan/komisi (*comission*) tertinggi pada kelas Tanah Industri (Ti) sebesar 9,3%. Akurasi penghasil tertinggi pada kelas Tanah Industri (Ti) sebesar 100%, dan akurasi pengguna tertinggi pada kelas Tanah Pertanian (Tp) sebesar 97,83%.

Matriks kesalahan hasil klasifikasi dengan skema penggunaan lahan 8 kelas (level II) terbaik, diketahui bahwa besar akurasi keseluruhan (*overall accuracy*) pada hasil klasifikasi dengan skema penggunaan lahan level II diperoleh sebesar 95,75% dan kappa 0,95. Kesalahan penghilangan/omisi (*ommision*) tertinggi pada kelas Tegalan (Tg) sebesar 10,48%, dan kesalahan penambahan/komisi (*comission*) tertinggi pada kelas Kampung (Kp) sebesar 10,32%. Akurasi penghasil tertinggi pada kelas Tanah Industri (Ti) dan kelas Hutan (Hn) sebesar 100%, dan akurasi pengguna tertinggi pada kelas Sungai (Su) sebesar 100%.

Peta Penggunaan Lahan di Sebagian Kabupaten Purworejo

Hasil dari proses KDD berupa pengetahuan, dalam hal ini informasi penggunaan lahan. Dari proses *pattern evaluation,* diketahui pohon keputusan yang memiliki akurasi terbaik. Penelitian ini menghasilkan pohon keputusan terbaik dari CTA18 (Level I) dan CTA42 (Level II), hasil klasifikasi dari pohon keputusan tersebut kemudian dilanjutkan ke proses selanjutnya, yaitu *knowledge presentation*. Untuk merepresentasikan atau memvisualisasikan pengetahuan, maka dalam penelitian ini pengetahuan tersebut disajikan dalam bentuk peta, yaitu Peta Penggunaan Lahan. Untuk Peta Penggunaan Lahan Level I Tahun 2013 di Sebagian Wilayah Kabupaten Purworejo, sedangkan Peta Penggunaan Lahan Level II Tahun 2013 di Sebagian Wilayah Kabupaten Purworejo pada Gambar 4.31. Sebelum disusun menjadi peta penggunaan lahan, terlebih dahulu dilakukan *filter majority* untuk memperhalus tampilan peta. Peta penggunaan lahan yang disajikan tersebut setara dengan skala 1:100.000.

Penerapan Hasil Pohon Keputusan pada Daerah Lain

Hasil pohon keputusan dari training sebelumnya, dapat dimanfaatkan pada daerah lain yang memiliki kemiripan karakteristik. Dalam penelitian ini akan mengambil daerah di sebelah barat Kabupaten Purworejo yang memiliki kemiripan karakteristik, yaitu Kabupaten Kebumen. Pada Kabupaten Kebumen daerah penelitian juga dipotong menjadi 700x700 piksel. Sebelumnya dilakukan data *pre-processing* terlebih dahulu, kemudian data-data baru tersebut dapat digunakan sebagai masukan dari pohon keputusan. Hasil dari pohon keputusan tersebut juga berupa klasifikasi penggunaan lahan. Kemudian untuk mengetahui tingkat akurasi dalam penerapannya pada daerah lain maka hasil klasifikasi tersebut juga dilakukan uji akurasi.

Penelitian ini dalam mengambil sampel uji akurasi dengan melakukan interpretasi citra. Menggunakan beberapa komposit citra Landsat-8 OLI serta menggunakan bantuan dari citra *Digital Globe Google Earth* yang memiliki resolusi lebih tinggi, untuk mengidentifikasi objek. Pohon keputusan yang digunakan pada daerah lain ini menggunakan pohon keputusan terbaik dari masing-masing tingkat skema klasifikasi, yaitu CTA 18 (Level I) dan CTA 42 (Level II). Dalam mengeksekusi pohon keputusan dari learning (pembelajaran) sebelumnya, penelitian ini menggunakan *software ENVI 5.1* menggunakan modul Decision Tree. Menyusunnya sesuai dengan pohon keputusan yang diperoleh dari pembelajaran pada IDRISI Selva 17.02. Pohon keputusan pada ENVI.

Pohon keputusan yang telah dibentuk tersebut kemudian diberi masukan parameter-parameter yang digunakan pada setiap *node*, sesuai dengan daerah baru yang akan dilakukan klasifikasi. Pohon keputusan tersebut kemudian dieksekusi, sehingga menjadi klasifikasi penggunaan lahan. Hasil dari klasifikasi penggunaan lahan dengan skema penggunaan lahan level I pada daerah lain ini kemudian perlu diketahui tingkat akurasinya menggunakan matriks kesalahan. Besar akurasi keseluruhan (*overall accuracy*) pada hasil klasifikasi dengan skema penggunaan lahan level I diperoleh sebesar 93,27% dan kappa 0,8923. Kesalahan penghilangan/omisi (*ommision*) tertinggi pada kelas Perairan Darat (Pd) sebesar 76,32%, dan kesalahan penambahan/komisi (*comission*) tertinggi pada kelas Perairan Darat (Pd) sebesar 47,06%. Hal ini cukup buruk dikarenakan banyak kelas Perairan Darat yang salah terklasifikasi menjadi kelas Tanah Pertanian. Akurasi penghasil tertinggi pada kelas Tanah Industri (Ti) sebesar 100%, dan akurasi pengguna tertinggi pada kelas Perkampungan (Pk) sebesar 96,2%. Terdapat penurunan akurasi keseluruhan jika dibandingkan dengan klasifikasi pada daerah di sebagian Kabupaten Purworejo, dengan selisih 3,44%. Secara umum hasil klasifikasi penggunaan lahan dapat diterima karena akurasi keseluruhan lebih dari 90%, namun pada kelas Perairan Darat (Pd) perlu dilakukan penelitian lebih lanjut karena mendapatkan akurasi yang rendah.

Besar akurasi keseluruhan *(overall accuracy)* pada hasil klasifikasi dengan skema penggunaan lahan level II diperoleh sebesar 91,36% dan kappa 0,8979. Kesalahan penghilangan/omisi (*ommision*) tertinggi pada kelas Sungai (Su) sebesar 42,11%, dan kesalahan penambahan/komisi (*comission*) tertinggi pada kelas Hutan (Hn) sebesar 17,65%. Hal ini dikarenakan adanya kemiripan nilai pada kelas Sawah yang sedang diairi dengan kelas Sungai, serta pada kelas Hutan dengan kelas Kebun Campuran. Akurasi penghasil tertinggi pada kelas Tanah Industri (Ti) dan kelas Kampung (Kp) sebesar 100%, dan akurasi pengguna tertinggi pada kelas Perumahan (Pr) sebesar 100%.

Skema P.L Level II terdapat penurunan akurasi keseluruhan jika dibandingkan dengan klasifikasi pada daerah di sebagian Kabupaten Purworejo, dengan selisih 4,39%. Secara umum hasil klasifikasi penggunaan lahan dapat diterima karena akurasi keseluruhan lebih dari 90%. Tetapi pada kelas Sungai (Su) perlu dilakukan penelitian lebih lanjut karena mendapatkan akurasi yang cukup rendah.

Penurunan akurasi dari daerah penelitian di sebagian wilayah Kabupaten Purworejo ke daerah penelitian lain di sebagian wilayah Kabupaten Kebumen dapat disebabkan karena terdapat perbedaan karakteristik penggunaan lahan, terutama pada kelas sungai meskipun secara umum memiliki kemiripan. Hal ini dapat dimungkinkan juga kurangnya variasi pada saat pengambilan sampel kelas sungai pada daerah penelitian yang menjadi training. Kurangnya variasi sampel pada kelas sungai ini juga dikarenakan tidak mudahnya pengambilan sampel kelas sungai. Dimana lebar sungai pada umumnya hanya terekam sebesar 1 piksel, sehingga sering bercampur dengan vegetasi yang pada umumnya berada di sisi kanan-kiri sungai. Serta adanya kemiripan karakteristik sungai dengan sawah yang sedang diairi.

Kemiripan kelas kebun campuran dengan kelas hutan dimana terdapat vegetasi berbatang keras dan rapat, memiliki ciri-ciri mirip pada penutup lahannya juga menyebabkan akurasi pengguna kedua kelas tersebut di bawah 85%. Kelas hutan biasanya pada daerah curam dimana masyarakat tak mudah menjangkaunya sehingga jarang dimanfaatkan oleh masyarakat. Sedangkan pada kelas kebun campuran biasanya pada daerah yang agak curam, sehingga masih dapat diakses oleh masyarakat. Pada kelas tersebut biasanya selain pohon-pohon berbatang keras biasanya terdapat tanaman-tanaman lain yang dimanfaatkan masyarakat, seperti ketela, pisang, dan jagung. Sebelum disusun menjadi peta terlebih dahulu dilakukan filter majority untuk memperhalus tampilan peta. Peta tersebut setara dengan skala 1:100.000.

Kesimpulan

Pengaruh parameter-parameter terhadap hasil klasifikasi dalam penelitian, antara lain adalah sebagai berikut:

a. Kombinasi parameter terbaik terdapat pada skema klasifikasi Level I (5 kelas) adalah atribut pemisah *Gini, pruning* 1%, dan filter tekstur dengan jendela bergerak 5x5, yaitu dengan akurasi 96,71%, *kappa* 0,9504. Untuk skema klasifikasi penggunaan lahan Level II (8 kelas) kombinasi parameter terbaik adalah atribut pemisah *Gini, pruning* 1%, dan filter tekstur 5x5, dengan nilai akurasi 95,75%, kappa 0,95
b. Rasio menjadi parameter pemisah paling stabil dengan rata-rata akurasi 93,16%, maksimum 95,88%, dan minimum 89,85%. Parameter pemisah yang memiliki akurasi terbaik (tertinggi) adalah *Gini.* Rata-rata proses klasifikasi yang memerlukan waktu lebih lama adalah pada parameter pemisah Rasio.
c. Skema klasifikasi dengan kelas yang lebih detil dalam hal ini 8 kelas penggunaan lahan (skema P.L Level II) memiliki akurasi lebih rendah jika dibandingkan dengan

skema klasifikasi dengan 5 kelas penggunaan lahan (skema P.L Level I).

d. Parameter *pruning* dengan rata-rata akurasi lebih tinggi adalah 1%.
e. Filter tekstur dengan jendela bergerak 5x5 memiliki rata-rata tingkat akurasi lebih tinggi jika dibandingkan dengan jendela bergerak 3x3.
f. Tidak semua data masukan yang diberikan dimanfaatkan oleh CTA dalam proses klasifikasi, dari 34 data masukan yang diberikan untuk Skema Level I dengan akurasi terbaik menggunakan 14 data masukan sedangkan Skema Level II menggunakan 17 data masukan sebagai simpul pemisah.

Rata-rata akurasi keseluruhan simulasi CTA sebesar 92.92% dan *kappa* 0.9066, akurasi maksimum metode CTA sebesar 96,71%, kappa 0,9504, dan akurasi minimum 89,44%, kappa 0,867. Rata-rata waktu proses eksekusi sebesar 6,913 detik, sehingga metode CTA memerlukan waktu proses yang cukup cepat untuk mengolah 34 data masukan dengan ukuran 700x700 piksel. Hasil dari KDD yang diterapkan pada daerah lain dengan karakteristik mirip, menghasilkan akurasi keseluruhan 93,27% dengan kappa 0,8923 untuk Skema P.L Level I, sedangkan untuk Skema P.L Level II menghasilkan akurasi keseluruhan 91,36% dengan kappa 0,8979. Dari tingkat akurasi terbaik yang diperoleh dalam penelitian ini maupun penerapan hasil pembelajarannya pada daerah lain, dimana lebih besar dari 90% yang menjadi persyaratan minimal untuk terapan kebijakan penggunaan lahan, maka metode non-parametrik CTA dengan teknik data mining menggunakan citra Landsat-8 OLI dapat digunakan sebagai alternatif metode untuk klasifikasi penggunaan lahan berbasis penutup lahan setara dengan skala 1:100.000.

Hipotesis pertama dalam penelitian ini tidak terbukti, parameter pemisah rasio tidak menghasilkan akurasi terbaik dalam penelitian ini. Karena dalam penelitian ini parameter pemisah gini yang memperoleh akurasi terbaik. Hal ini dimungkinkan karena pada parameter pemisah rasio sedikit mengalami *overfitting* dibandingkan dengan parameter gini pada akurasi terbaiknya. Walaupun demikian parameter rasio menjadi parameter paling stabil dalam 48 simulasi penelitian dengan rata-rata akurasi tertinggi. Tidak semua data masukan digunakan oleh CTA untuk menentukan suatu kelas penggunaan lahan, dari 34 data masukan pada akurasi terbaik skema Level I terbaik membutuhkan 14 data masukan, sedangkan skema Level II terbaik membutuhkan 17 data masukan. Hal ini dikarenakan ketidakmurnian (*impurity)* data tersebut untuk dijadikan node pemisah pohon keputusan.

Hipotesis kedua dalam penelitian ini terbukti, dimana akurasi keseluruhan penelitian lebih dari 90%, dengan akurasi terbaik pada Kabupaten Purworejo sebesar 96,71% dan akurasi terbaik pada Kabupaten Kebumen sebesar 93,27%.

Pengolahan Citra Satelit untuk Menilai Risiko Degradasi Tanah di Daerah Perkebunan Kelapa Sawit

Satellite Image Processing for Assessing Land Degradation Risk on the Oil Palm Plantation Area

Nama	: Diah Dzihrina
NIP	: 198511132009032005
Instansi	: BPN
Tahun Intake	: 2013
Tingkat Beasiswa	: Master Overseas
Program Studi	: MSc Geographical Information Systems
Negara Studi	: Britania Raya
Universitas	: University of Leeds

ABSTRAK

Dalam penelitian ini, dua analisis deteksi perubahan selanjutnya diterapkan untuk menilai dan memantau risiko degradasi lahan pada areal perkebunan kelapa sawit di Desa Seikijang dan Langgam, Kabupaten Pelalawan, Provinsi Riau, Indonesia: klasifikasi garis pos dan perbedaan indeks. Pertama, empat citra satelit Landsat yang diperoleh dari berbagai kurma: 1996, 2001, 2007, dan 2013 dikelompokkan menjadi lima kelas yang berbeda yang mewakili fase pengembangan kelapa sawit. Analisis pasca klasifikasi kemudian diterapkan untuk mendapatkan "dari - ke" perubahan informasi yang terjadi di areal perkebunan. Kedua, indeks yang mewakili substitusi degradasi lahan, vegetasi indeks perbedaan normalisasi (NDVI), transformasi dan tegangan tembolok (TCT) basah dan kecerahan, dan indeks kemerahan (RI) dihitung. Untuk menilai perubahan pada indeks, perbedaan citra antara interval tahun 1996 sampai 2001, 2001 sampai 2007, dan 2007 sampai 2013 diterapkan. Perubahan negatif yang terdeteksi dari keempat indeks ini dan perubahan informasi yang berasal dari analisis pasca klasifikasi kemudian digunakan untuk menunjukkan daerah yang terkena dampak risiko degradasi lahan. Antara interval tahun 1996 sampai 2001, 2001 sampai 2007, dan 2007 sampai 2013, total area yang terkena dampak perubahan indeks adalah sekitar 2180 Ha, 2190 Ha, dan 3105 Ha, dengan sekitar 70% disebabkan oleh konversi kawasan vegetasi menjadi area kliring lokasi

Kata kunci: Perkebunan kelapa sawit, deteksi perubahan, klasifikasi pasca, perbedaan citra.

ABSTRACT

In this study, two subsequent changes detection analyses were applied to assess and to monitor land degradation risk on the oil palm plantation area in Seikijang and Langgam Villages, Pelalawan Regency, Riau Province, Indonesia: post-classification and indices image differencing. Firstly, four Landsat satellite imageries acquired from different dates: 1996, 2001, 2007, and 2013 were classified into five different classes representing oil palm development phases. Post-classification analysis then was applied to obtain "from – to" change information occurred in the plantation area. Secondly, indices representing land degradation proxies, normalized difference index vegetation (NDVI), tasselled cap transformation (TCT) wetness and brightness, and redness index (RI) were computed. In order to assess any change on the indices, image differencing between year intervals 1996 to 2001, 2001 to 2007, and 2007 to 2013 was applied. The negative changes detected from these four indices and the change information derived from post-classification analysis were then used to indicate areas that were affected by land degradation risk. Between year intervals 1996 to 2001, 2001 to 2007, and 2007 to 2013, total areas affected by the negative changes of indices were around 2180 Ha, 2190 Ha, and 3105 Ha, respectively with around 70% caused by the conversion of vegetated area into site clearing area.

Keywords: Oil palm plantations, change detection, post-classification, image differencing.

Oil palm (*Elaeis guineensis*) is a perennial crop, native to the West and Central Africa. It is suitable to be grown in areas that are located 0 – 500 m of altitude, having 25 – 28^{0} C of temperature, with 1700 – 2500 mm of annual rainfall rate and that are exposed to an abundant amount of sunshine (Corley and Tinker, 2003). Besides Africa, this type of areas can also be found in the regions located along the equator such as South Asia, South East Asia, and South America.

Oil palm can be benefitted from its fruits and seeds. Oil palm fruits can be extracted to be made into palm oil that is often used as an ingredient for edible products like vegetable oil, margarine, and chocolate. Oil palm seeds can be extracted to be made into palm kernel oil that is mostly used as an ingredient for non-edible products such as cosmetics, soaps, and detergents (Sheil et al., 2009). Besides being used in the manufacturing of food products and the above mentioned non-edible products, the development of oil palm plantations has also been intended to meet the demands of biodiesel and other alternative sources of energy, over the past few years.

The total production and demand of general palm oil, has been increasing annually worldwide, according to The United State Department of Agriculture (USDA). USDA (2014) reports that in the year of 2014/2015, total global palm oil production is estimated to reach 62,348 thousand metric tons. This estimation indicates a considerable increase in production, by around 13,500 thousand metric tons, in comparison to the year of 2010/2011. Meanwhile, the total domestic consumption of palm oil around the globe in 2014/2015 is expected to reach 60,487 thousand metric tons from 47,228 thousand metric tons in 2010/2011. According to Food and Agricultural Organisation of the United States (FAO) (2013) the total area of oil palm plantation worldwide is 16.4 million hectares spread over 27 countries. Indonesia and Malaysia are the leading oil palm producers in the world and contribute around 47% and 32%, respectively, to the total area of oil palm plantations in the world (Gunarso et al., 2013).

The development of oil palm plantations is not without altercations due to its several adverse consequential impacts. As oil palm plantation productions are often started by changing primary forest functions, deforestation followed by the negative impact on biodiversity and indigenous communities become the main issues (Wakker, 2005). In addition, further studies also indicate that the development of oil palm plantations contributes to other environmental impacts on climate and land (UCSUSA, 2013; Sheil et al., 2009; Lord and Clay, 2009). Recent studies on deforestation, biodiversity loss, social livelihood and climate change are sufficiently documented. However, studies regarding oil palm plantation in association with land degradation are limited and it is often generalised from other tree crop (Shei, 2009; Hartermink, 2005). The occurrence of land degradation in oil palm plantation alone might not be impracticable as land degradation can be resulted from deforestation and over-cultivation of land, as well (Stocking and Murnaghan, 2001). Clearing of land during the rainy season and developing oil palm plantation on unsuitable land with steep slopes are the causes of land degradation risks on the oil palm plantation areas (Lihawa and Utina, 2009). In addition, poor conservation of the plantation and abandoning the plantation will most likely increase the risk of degradation. Therefore, exploring the extent of land degradation on oil pal plantations is necessary as its impacts will most likely reduce both quality of the land and productivity of the plantation (Stocking and Murnaghan, 2001).

Generally, land degradation assessment can be accomplished using several techniques. Besides direct field observation, remote sensing technology has also been successfully used to assess land degradation for various different types of spatial and temporal domain (Ravishankar and Sreenivas, 2007). The availability of fine resolution satellite images, such as the Landsat series, and various remote sensing techniques enable us to detect, monitor and analyse the magnitude and the extent of land degradation within certain periods of time.

Image Classification and Accuracy Assessment

The number of classes decided to be used in the classification process was based on the generic oil palm plantation development phases. Generally, the development of oil palm plantation can be classified into four phases. The first phase is land clearing. In this phase, land is cleared so that there is no more vegetation and other land cover features covering the land. The next phases can be categorised based on the age of the plants (Aswandi, 2012). Plantations covered by 0–3 years old oil palm plants can be grouped as immature or newly planted phase. The third phase is intended for oil palm plants having age between 3–7 years called young phase and the ones that are more than 8-20 years old can be categorised into the mature phase. In term of physical appearance, by using colour composite RGB combination of band 5, 4, and 2, the third first phase can be distinguished by visual interpretation based on their colour and texture. The Land clearing phase can easily be detected by the appearance of bare land which has red – brown colour. The immature phase can be identified as it has white-green or white-yellow colour with soft texture. Yellow-green and light green colour with soft texture can be used to identify the young phase and the colour green and a relatively rough texture can be used to identify the mature phase. The following figure 3 represents the appearance of the four phases.

Besides using the development stages, another land cover feature which was desired to be included in the classification was that of water bodies as feature like river was shown in the images. As the images were free from human made features such as built up area, only five classes were identified to categorise all pixels in the images into five themes. While performing the ISODATA algorithm, a maximum of 20 iterations with 0.95 of convergence threshold was set. This meant that during the iteration step the clusters kept merging or splitting until the predefined threshold was approached.

The overall accuracy and overall kappa statistics were relatively good, above 75%. The overall accuracy of classified image of 1996, 2001, 2007, and 2013 were 84%, 76%, 76%, and 78.67% respectively. The overall accuracy refers to the total number of correctly classified pixels divided by the total number of reference pixels. Meanwhile, the kappa statistics of individual images shows the agreement between predicted classes and reference data from 1996, 2001, 2007 and 2013 which were 0.7531, 0.6279, 0.6633, and 0.7041 respectively. The degree of agreement of kappa alone varied between 0 and 1.0 indicating no agreement to be a perfect agreement (Mather, 2004). Producer's and user's accuracy implies the proportion of the area in each class classified correctly on the ground and the proportion of area in each class in the classified images identified correctly as the same class on the ground. Based on the summary of accuracy assessment table, the young plantation obtained relatively low percentage for both producer'sS and user's accuracy. There were some possible reasons related to this matter. Referring to the classification result of 2001 image, there were areas that should have been classified as forest or mature plantation instead of young plantation. Unlike other images derived in May and June, the image of 2001 was acquired in March. Even though the acquisition was at the end of the rainy season which implies that the intensity of rainfall was not as high as in the peak rainy season (December and January), such a phenological effect could not be avoided. Phenology is generally defined as the life cycle events of plants being affected by meteorological variations such as accumulated precipitation, temperature, growing degree days, and humidity (Weber, 2001). As plant canopy might change due to the meteorological variations impact, the value of reflectance properties particularly visible red and near infrared spectrum absorbed and reflected by the plants also changed (USGS, 2011). Thus, when it came to the unsupervised classification process, the algorithm tended to group spectrally homogenous pixels into the same classes instead of classifying the pixels based on the analyst's interests (Campbell and Wynne, 2011). In addition, the mean of pixels, when seen spectrally, for each band classified as young plantation and forest or mature plantation was slightly different. That misclassification also occurred in the 2007 image. The area which was previously identified as immature plantation was classified as water. This can be caused by shadows affecting spectral response from the surface features. Objects influenced by shadows might appear both darker and bluer when they are fully illuminated (Lillesand and Chipman, 2009).

The other possibility as to why the pixels were not well classified was that of them being mixed pixels. Pixels containing mixed spectral information are common in the remotely sensed data (Asis and Omasa, 2007). As all the images had 30 meters of spatial resolution, it was unavoidable that pure pixels were rarely obtained from all sections of each image. The mixed pixels alone could generally be found on the edges of large objects and hence the size of the object was smaller compared to its spatial resolution (Gebbinck, 1998). In this study alone spectral mixed information could be found in the immature plantation class containing exposed soil, young plantation class which might consist of a mixture of canopy from mature or immature classes, and on the edges of water body. Since for the classification process all pixels were treated as pure pixels, reduction in accuracy might occur particularly when the random samples generated on the accuracy assessment fall in the mixed pixels which are classified differently as the reference data. The degree of inaccuracy might be worse when the number of mixed pixels was very large.

The use of higher spatial resolution could be suggested to obtain better image interpretation. However, it may not necessarily offer better results in the image classification process. As revealed by Campbell and Wynne (2011), finer resolution captures features in more detail in comparison to coarser image resolution. Therefore, rather than decreasing, finer resolution might increase the number of mixed pixels. To resolve the problem of mixed pixels, sub-pixels classification techniques could be considered (Mather, 2004)). Basically, this technique works by assigning mixed pixels with more than one label.

NDVI computation

The results of NDVI computations varied from 0 to 0.805 for the year 1996, -0.180 to 0.777 for 2001, -0.319 to 0.812 for 2007, and -0.193 to 0.617 for the year 2013. The negative values found in the last three images were because of the existence of the areas identified being inundated by water. Generally, NDVI could effectively distinguish oil palm development phases. Areas having higher value of NDVI (> 0.6) would indicate forest/ mature plantation and young plantation, while areas having NDVI value nearly 0.1 up to 0.3 would often be detected as site clearing areas. In this study, the range of NDVI value indicating immature plantation class tended to be fuzzy as it was often mixed by both site clearing and young plantation class. The extraction of NDVI value in this class was 0.3 – 0.7.

TCT Brightness and Wetness Computation

In terms of TCT brightness and wetness, according to Mather (2004), the values for these two indices should be scaled between 0–350 and -150–75, respectively. However, because this study was intended to analyse multi-date TCT images comparison, as suggested by Huang et al. (2002) that in order to minimize the effect of variation in the composition of atmosphere and illumination geometry change, conversion from digital number to reflectance should be accomplished. As a result the range of both TCT brightness and wetness was not exactly laid in the scales mentioned by Mather.

The ranges of TCT brightness values of the 1996, 2001, 2007, and 2013 images were 11.403 to 16.052, 1.313 to 7.4083, 11.503 to 16.192, and 0.147 to 0.68636, respectively. Meanwhile, the range of TCT wetness for four different date images was -5.183 to -2.547 for 1996 image, -3.998 to 0.260 for 2001 image, -7.131 to -2.617 for 2007 image, and -0.211 to 0.130 for the image from 2013.

In terms of the brightness pattern, area exposed due to being covered only by bare soil tended to be brighter compared to the area covered by vegetation both dense, like in the forest or mature plantation class, and relatively sparse, like in the immature plantation class. As the images of 1996 have larger area exposed due to bare soil, larger proportion of area appeared brighter as can be seen in the following image (figure 8).

Meanwhile, in terms of wetness pattern, the lower wetness value tended to be found in the areas classified as site clearing and immature plantation. The Areas covered by dense vegetation like forest or mature plantation and young plantation generally showed higher wetness value. Wetness alone indicated the moisture level of the soil and vegetation. Under normal circumstances, getting higher wetness value meant the area was well moistured. On inspecting some pixel samples, it was identified that the pixels having lower brightness value tended to have higher wetness value. Conversely, pixels with lower wetness value tended to have higher brightness value.

Redness Index Computation

The ranges of the Redness Index (RI) value for the four different images were 0 to 1.887 for the 1996 image, 0 to 1.741 for the 2001 image, 0 to 1.526 for the 2007 image, and 0 to 1.697 for the 2013 image. In term of average values, there was a similarity between the four images. The range of the average value was around 0.37 to 0.4. The area covered by vegetation tended to have lower value compared to the area exposed by bare soil. The value of RI in the dense vegetation or forest and mature plantation class was less than 0.4, while in the site clearing area was nearly 1 and more than 1. Immature plantation tended to have medium value around 0.5 to 0.8. Visually, the higher value of redness index would be presented in the brighter colour which could indicate any decrease in organic matter within the region.

Image Differencing

There were three indices differencing images derived from four individual indices computations. The changes were carried out between images of 1996 and 2001, 2001 and 2007, and 2007 and 2013 respectively. In order to determine the change and no change area, trial and test methods were applied to determine threshold boundaries.

The best fitting threshold was selected based on the visual analysis of the two raw images (Mancini et al., 2014).

For NDVI differencing, the best fitting threshold to highlight the change and no change in the plantation area was 1·σ for the changes between 1996–2001 and 2001-2007, and 1.5.σ for 2007 -2013 image, with σ values for each interval images being 0.135, 0.111, and 0.106, respectively. Unselected thresholds were not used to delineate the change and no change area because they excessively highlighted positive changes instead of negative changes.

Threshold of 1.σ, with σ values 0.412, was selected to differentiate change and no change of TCT brightness for 1996–2001, while for 2001-2007 and 2007-2013 the same threshold of ± 2.σ, with σ were 0.356 and 1.231 were selected. The TCT brightness differencing should be used to highlight area covered by dense vegetation converted into site clearing. However, in this study, instead of detecting the changes from vegetated area to exposed land, the TCT brightness differencing tends to highlight the changes occurred from and to vegetated area only.

The decrease of wetness value alone indicated negative change in which both vegetation cover and soil became less moist than before. Meanwhile, the increase of wetness value could be used to indicate positive change in areas that were previously drier. Selected threshold for TCT wetness was 1.5.σ for all differential images. The σ value for the three interval images from 1996 to 2013 were 0.55, 0.591 and 0,592, respectively. This threshold was selected as it could highlight necessary changes which could not be done by other thresholds. Threshold with n factor less than 1.5, for example, excessively highlighted the decrease in wetness value particularly in the area covered by vegetation. A similar case occurred in the RI threshold selection, as well. Therefore, the most suitable thresholds for RI differencing were 1σ, with σ value 0.183 for 1996 to 2001 and 2001 to 2007 and 1.5σ, with the σ values 0.138 and 0.140, respectively.

In terms of the relationship between each index of the change detection process, based on the inspection of some pixels, it was found that an increase in the NDVI value would be followed by the increase in the TCT wetness, and a decrease in TCT brightness and RI. Likewise, positive change caused by the improvement of vegetation cover would be followed by the positive change of TCT wetness and respective negative changes of TCT brightness and RI.

Linking the Oil Palm Development with Land Degradation

The main focus in this study was to detect land degradation. Thus, in this section the negative changes identified in the image differencing results which could lead to the degradation risk would be highlighted. With reference to the indices differencing results, the negative changes could be considered as the decrease of NDVI value, the decrease of TCT wetness, the rise of TCT brightness, and the increase of RI value. The negative changes caused by the decrease of NDVI value could reflect the degradation in the vegetation ecosystem, whereas the decrease of TCT wetness could be associated with the decrease of surface moisture, both for vegetation cover and soil. The negative change caused by the rise of TCT brightness and RI means the decrease in content of the soil organic matter. In order to examine the land degradation risk on the oil palm plantation area, the relationship between the negative changes of each index and the oil palm development phases was examined. This was done by converting indices differencing and post-classification results into polygon vector based formats. The magnitude of land degradation risk could be derived by overlying the polygon of negative changes with the polygon of post-classification results.

The spatial distribution of negative changes, indicated by four indices, and its relation to the oil palm development phases could be seen in the following figure 9. Meanwhile, the detailed information on total area and percentage of negative changes of each index in relation to the change of oil palm plantation development phases are presented in table 4 to table 6 as follows. As post-classification analysis resulted 25 combinations of "from – to" change information, the "to class" field was considered as a summary of the five original classes (from) which changed to the new classes (to). The total area affected by negative changes of all indices would be different from the summation of negative changes of each index. This is because the negative changes of each index might occur in the same area.

For change detection between 1996 and 2001, total area affected by the negative changes of indices differencing was 2188.69 Ha with a particular contribution from TCT wetness, NDVI, and RI. In comparison with the other two indices, the TCT wetness had bigger contribution on total negative changes. Total area suffering by the decrease of TCT wetness was around 2100 Ha. The effect on around 50% of this area generally resulted from the phenological changes of young plantation to immature plantation and immature plantation to immature plantation. Meanwhile, 40% of the area was effected due to exposing vegetation area to bare land. Negative changes caused by the decrease of NDVI affected around 720 Ha where 70% of this area resulted from the vegetation clearing process. Similarly, around 735 Ha of area affected by the rise of RI value resulted from the conversion of vegetated area into site clearing area.

Another class considerably affected by the negative changes of the indices was that of the immature plantation. Around 141 Ha and 1100 Ha of area in this class were impacted by the decrease of NDVI and TCT wetness, respectively. A similar pattern was found in the change detection between the year of 2001 and 2007. Around 2190 Ha of area was affected by the negative changes of the four indices. The decrease of NDVI and the rise of RI were the main contributor proxies of the land degradation risk with total affected area of around 1600 Ha and 1400 Ha, respectively. Both negative changes caused by NDVI and RI were mainly influenced by vegetation clearing process and area being exposed by bare soil, around 70% and 75%, respectively. The area identified as affected by the negative changes caused by the TCT wetness was only around 2 Ha which was contributed from the conversion of forest/mature plantation, young and immature plantation into bare lands. As the total area of site clearing class detected in the post classification process was around 1600 Ha, the TCT wetness seemingly did not work properly in identifying the decrease of the wetness value. The other negative change was identified by TCT brightness. However, instead of detecting soil background reflectance such as bare and moderately covered soil, 90% of the changes identified by the TCT brightness were relatively dense vegetation classified as immature plantation. This was because of a wide discrepancy in the range of TCT brightness value between 2001 and 2007.

For change detection between 2007 and 2013, negative changes were identified by only three indices; TCT wetness, NDVI, and RI. Compared to the two other change-detection intervals the total area of negative change increased to 3105 Ha. The decrease of wetness value contributed the biggest proportion of negative changes; with total area of around 2671 Ha affected. The negative change of the TCT wetness alone mainly occurred in the area classified as forest and mature plantation and the site clearing which was resulted from forest conversion. Total area detected as affected by the negative change caused by the decrease of NDVI value was around 800 Ha with around 79% caused by forest clearing. Likewise, around 850 Ha of area was affected by the rise of RI with 78% caused by the conversion to site clearing class.

Low percentages of negative changes were also identified in the areas where immature plantation was being changed into water body class. Take negative changes resulted by the decrease of NDVI between 2007 and 2013 on the water body class, for example. As the river feature representing the water body class was masked out of the image differencing computation, the 3.5% of negative change on this class was basically the remaining pixels along the edge of the river which was not being masked. The other example was identified based on the negative changes by NDVI in the young plantation class between 2007 and 2013. As the percentage and the area of negative change in this class were very low, 0.04% and 0.31 Ha respectively, it could be assumed that this was the residual effect of the thresholding process.

The findings of this study were in line with several previous researches such as that of Lord and Clay (2005) employing USLE to evaluate the impact of the development of oil palm plantation on the land in Papua New Guinea. Lord and Clay stated that the degree of erosion was higher after forest clearance and remained high during the oil palm establishment particularly when the soil was left uncovered. Once this area was covered by oil palm canopy or converted into immature plantation, the degree of soil erosion would be limited (Hetermink, 2005). Therefore, the negative changes of indices were also identified in the area classified as immature plantation.

In term of remote sensing indices used in this study, all indices, except TCT brightness, provided a good data support to identify land degradation risks. Originally, TCT brightness was designed to detect sites with soil reflectance (Morain et al., 2010). However, as mentioned in the previous explanations (section 4.5), instead of detecting soil background reflectance such as bare and moderately covered soil, TCT brightness tended to highlight the changes in the vegetated area. This was possible because all coefficients to derive TCT brightness were positive (Adams et al, 2009). Thus, brightness would remain to be shown as even though the ground surface did not include soil. As the study area is mostly covered by vegetation and soil with high organic matter, the difficulty to distinguish bright soil from dark green vegetation might occur when the brightness of the soil and the greenness of the vegetation increase at the same time (Huang et al., 2002). Therefore, using TCT brightness to detect land degradation risk in the dense vegetation area might give misleading results.

The detection of land degradation risk by using the three other indices, logically matched with the changes occurring on the ground surface. However, since this study only used four different multi-temporal images, the negative changes identified by the indices need not have necessarily indicated the trend of land degradation (Bai et al., 2008). This was because the changes of the indices could not be separated from the oil palm life cycle and climatic variations such as the amount of precipitation, temperature, and sunshine. Longer study periods with shorter interval dates of remotely sensed images might be required to identify the real trend of land degradation in the oil palm plantation area.

As the ground data was not available, accuracy assessment to evaluate change detection result based on image differencing was not conducted. However, it was worth noting that this process could not be separated from several possible sources of errors (Lin et al., 2008). These involved radiometric calibration conducted in the pre-processing step, image selection including the consideration to select images derived on the same month in order to avoid phenological effect, confusion due to mixed pixels, error in vectorisation, and threshold selection when performing change and no change detection.

After employing image differencing technique, it could be concluded that this technique offered several advantages. Since this technique has straightforward image subtraction concept, image differencing was easy to be implemented. In addition, its result was also uncomplicated to be interpreted. The only main issue regarding image differencing is that this technique is highly sensitive to the threshold selection and might be subjective dependent on the image analyst. Applying different thresholds would result in different change and no change detections. Thus, the threshold should be appropriately selected to avoid bias in change detection result.

Conclusion

This study was conducted to assess land degradation risk on the oil palm plantation area. To do so, change detection analysis was carried out by employing four different dates of remote sensing imageries, 1996, 2001, 2007, and 2013, respectively, acquired from Landsat satellite. The overall analyses were conducted on the basis of land degradation proxies analysis, vegetation disturbance, soil moisture, and soil colour, derived from the remote sensing indices. Vegetation disturbance was analysed by using normalised difference vegetation index (NDVI). Soil moisture was observed by using tasselled cap transformation (TCT) wetness, whereas soil colour was assessed by employing TCT brightness and redness index (RI).

Change detection analysis, based on the image differencing and thresholding techniques, was conducted to evaluate the changes of indices between year intervals- 1996 to 2001, 2001 to 2007, and 2007 to 2013, respectively. The negative changes detected from these four indices were then used to indicate areas that were affected by land degradation risk. Prior to this analysis, individual image classification process, based on the ISODATA algorithm for the four images, was used to segment the area over the oil palm plantation into 5 classes, based on the oil palm plantation phases. These classes included water body, forest/ mature plantation, young plantation, and immature plantation. An accuracy assessment was conducted to evaluate the degree of error of the classified image caused by incorrect labelling of the pixels. The accuracies for the four images from 1996 to 2013 were 84%, 76%, 76%, and 78.67%, respectively.

Following the image classification process and accuracy assessment, a post-classification analysis was carried out to detect the changes of individual classification images between two date images. The result of this process was 25 combinations of "from – to" change information. This information was then linked to the negative changes of indices derived from the Image Differencing Process. The result showed that between year intervals 1996 to 2001, 2001 to 2007, and 2007 to 2013, total areas affected by the negative changes of indices were around 2180 Ha, 2190 Ha, and 3105 Ha, respectively with around 70% caused by the conversion of vegetated area into site clearing area.

In terms of the indices' performance, all indices except TCT brightness provided a good result to detect land degradation risks. TCT brightness tended to highlight the changes in the vegetated area, instead of the soil background. Therefore, using TCT brightness to detect land degradation risk in the dense vegetation area might give misleading results. The result showed that mainly land degradation risk occurred in the area where barren soil remained exposed and in the area that was converted into the site clearing class. Similar finding was presented by Lord and Clay (2005) mentioning that the degree of land degradation risk, based on the soil loss proxy, was higher after forest clearance and remained high during the oil palm establishment particularly when the soil was left uncovered. In addition, land degradation risk would be limited once the area was covered by oil palm canopies or were identified as immature plantation (Hetermink, 2005).

The detection of land degradation risk by using the three other indices, logically matched with the changes occurring on the ground surface. However, since this study only used four different multi-temporal images, the negative changes identified by the indices need not have necessarily indicated the trend of land degradation (Bai et al., 2008). This was because the changes of the indices could not be separated from the oil palm life cycle and climatic variations such as the amount of precipitations, temperature, and sunshine. Longer study periods with shorter interval dates of remotely sensed images as well as involving other parameters such as meteorological variations might be required to identify the real trend of land degradation in the oil palm plantation area.

Kajian Perubahan Penggunaan Lahan Berbasis Citra Satelit Penginderaan Jauh Resolusi Menengah dengan Metode Multi Layer Perceptron dan Markov Chain (Studi di Sebagian Kabupaten Bantul)

Analysis of Land Use Conversion with Medium Resolution Imagery Using Multi Layer Perceptron and Markov Chain Methods (Case Study: Parts of Bantul Regency)

Nama	: Diana Wisnu Wardani
NIP	: 198207142006042004
Instansi	: BPN
Tahun Intake	: 2012
Tingkat Beasiswa	: Master Local
Program Studi	: Pengindraan Jauh
Negara Studi	: Indonesia
Universitas	: Universitas Gadjah Mada

ABSTRAK

Perkembangan Kota Yogyakarta yang sangat pesat mempengaruhi perubahan penggunaan lahan di daerah *urban fringe* salah satunya adalah Kabupaten Bantul. Perubahan penggunaan lahan yang tidak terkendali akan menimbulkan masalah sosial ekonomi dan lingkungan. Penelitian mengenai kajian perubahan penggunaan lahan berbasis citra satelit penginderaan jauh resolusi menengah dengan metode *Multi Layer Perceptron* dan *Markov Chain* di sebagian Kabupaten Bantul ini bertujuan mengkaji kemampuan citra satelit penginderaan jauh resolusi menengah Landsat untuk ekstraksi informasi penggunaan lahan tahun 2002, 2009 dan 2013, mengkaji perubahan penggunaan lahan secara spasial dari tahun 2002 sampai dengan tahun 2009 serta menyusun pemodelan perubahan penggunaan lahan dengan metode Multi Layer Perceptron dan Markov Chain pada tahun 2013 dengan mempertimbangkan faktor-faktor yang mempengaruhi perubahan penggunaan lahan berdasar penggunaan lahan 2002-2009. Faktor-faktor yang mempengaruhi perubahan (variabel perubahan) penggunaan lahan meliputi aksesbilitas (kepadatan jalan, jarak terhadap jalan, jarak terhadap sungai) dan kesesuaian lahan (kemiringan lereng). Citra penginderaan jauh multitemporal dalam penelitian ini menggunakan citra Landsat 5™ tahun 2002, Landsat 7 ETM+ tahun 2009 dan Landsat 8 OLI tahun 2013.

Penelitian ini menggunakan klasifikasi multispektral dengan metode *maximum likelihood*. Klasifikasi multispektral menghasilkan peta penutup lahan (2002, 2009, 2013) yang selanjutnya diturunkan menjadi peta penggunaan lahan. Hasil perubahan penggunaan lahan 2002-2009 selanjutnya dikaji dan diintegrasikan dengan variabel perubahan sebagai input dalam regresi non linear dengan *Multi Layer Perceptron*. Besar probabilitas perubahan ditentukan dengan metode *Markov Chain.*

Perubahan penggunaan lahan dari lahan pertanian menjadi permukiman pada periode tahun 2002-2009 seluas 2.766,78 ha. Perubahan terluas terjadi di Kecamatan Banguntapan seluas 717,97 ha (25,21%). Perubahan kelas penggunaan lahan hutan dan kebun campuran ke permukiman seluas 804,69 ha dan perubahan terluas terjadi di Kecamatan Imogiri seluas 361,02 ha (6,63%). Pemodelan spasial dengan menggunakan kombinasi MLP dan MC menghasilkan akurasi hasil prediksi terbaik dengan *overall accuracy* 86,16 % dan nilai kappa sebesar 0,79 (substantial agreement).

Kata kunci : perubahan penggunaan lahan, prediksi, *multi layer perceptron, Markov chain*

ABSTRACT

The enormous development of Yogyakarta city contributes significant impact on land use change in urban fringe, including Bantul Regency. Whilst, an uncontrolled land use alteration will trigger to social, economy, and environmental problems. Thus, this research aims to analyze spatial land use change in some parts of Bantul Regency in time frame of 2002 to 2009. Moreover, this research attempts to create land use change model using Multi Layer Perceptron and Markov Chain in 2013 by considering some factors that affect the land use change. The factors are determined by analyzing accessibility (road density, distance towards road, distance towards river) and land suitability (slope). In addition, multi-temporal remote sensing images were used, including Landsat 5™ of 2002, Landsat ETM+ of 2009, ALOS AVNIR-2 of 2009, and Landsat 8 OLI of 2013.

This study uses multispetral classification by applying maximum likelihood method. Multispectral classification produces land cover map for 2002, 2009, and 2013 that was subsequently analyzed and integrated with change variables as inputs in non-linear regression in Multi Layer Perceptron. Then, the probability of change are defined by using Markov Chain method.

The result shows that 2766.78 ha farm land was altered into residential area in period of 2002 – 2009. The biggest change was occurred in Banguntapan Subdistrict with 717.97 ha (25.21%). Meanwhile, 804.69 ha of mixed plantation and forest were converted in residential land, with the largest change area located in Imogiri Subdistric (361.02 ha - 6.63%). In addition, the spatial model using the combined MLP and MC generates best prediction accuracy of 86.16 % and kappa value of 0.79 (substantial agreement). Therefore, the model can be applied to estimate the land use in 2016.

Keywords : land use change, prediction, multi-layer perceptron, Markov chain.

Metode *Artificial Neural Network* (ANN) saat ini semakin banyak digunakan untuk berbagai aplikasi. Metode *Artificial Neural Network* (ANN) atau jaringan syaraf tiruan merupakan metode *learning machine* (pembelajaran mesin) yang dapat mengenali pola dari masukan atau contoh yang diberikan dan juga termasuk ke dalam *supervised learning*. *Multi-layer Perceptron* (MLP) adalah salah satu bentuk arsitektur jaringan ANN yang paling banyak digunakan. MLP dapat diterapkan dalam analisis diskriminan non linier (untuk klasifikasi) dan sebagai fungsi regresi non linear (Chang, 2012). Selama ini MLP lebih banyak diaplikasikan sebagai metode klasifikasi. Karena bersifat non parametrik, MLP mampu mengakomodasi data nir-spektral yang digunakan sebagai data tambahan selain data spektral dalam proses klasifikasi multispektral (Danoedoro, 2012). Meskipun demikian belum banyak penelitian yang memanfaatkan MLP sebagai fungsi regresi, padahal MLP sebagai fungsi regresi mampu mendeteksi secara implisit hubungan nonlinier yang kompleks antara variabel dependen dan independen serta memiliki kemampuan untuk mendeteksi semua interaksi yang mungkin terjadi diantara variabel prediktor (Tu, 1996). MLP memiliki keuntungan menggambarkan hubungan yang ada antara variabel input dan output tanpa diketahui sebelumnya hubungan antara variabel-variabel itu sendiri.

Berbagai kombinasi metode telah dilakukan dalam kajian perubahan penggunaan lahan guna meningkatkan akurasi pemodelan. Dengan mempertimbangkan kelebihan dan kelemahan berbagai metode tersebut, penelitian dengan mengkombinasikan metode MLP dan MC untuk kajian perubahan penggunaan lahan perlu dicoba. Aplikasi metode MLP digunakan untuk mencari hubungan antara faktor-faktor yang mempengaruhi perubahan sebagai variabel bebas dan perubahan penggunaan lahan sebagai variabel terikat guna menghasilkan lokasi yang berpotensial mengalami perubahan. Kombinasi metode MLP dan metode MC menghasilkan prediksi penggunaan lahan di masa depan. Aplikasi metode MLP dikombinasikan dengan MC belum diketahui sejauh mana tingkat akurasi pemodelannya. Oleh karena itu dilakukan penelitian ini guna mengetahui tingkat akurasi pemodelan perubahan penggunaan lahan dengan metode MLP dan MC.

Perubahan penggunaan lahan memerlukan pengendalian agar tidak berdampak negatif bagi lingkungan. Perubahan tersebut dapat dipantau dan diprediksi melalui suatu pemodelan spasial. Pemodelan spasial perubahan penggunaan lahan telah banyak dikembangkan dengan memanfaatkan data penginderaan jauh dengan berbagai pendekatan.

Faktor-faktor yang mempengaruhi perubahan penggunaan lahan juga perlu diperhitungkan dalam pemodelan spasial perubahan penggunaan lahan. Kompleksitas faktor yang mempengaruhi dan bersifat non linear memerlukan pendekatan regresi non linear untuk mencari hubungan antara faktor yang mempengaruhi sebagai variabel bebas dan perubahan penggunaan lahan sebagai variabel terikat.

Interaksi antara faktor-faktor mempengaruhi perubahan dengan perubahan penggunaan lahan dalam jangka waktu tertentu dapat dimodelkan secara spasial dengan Multilayer Perceptron (MLP). MLP adalah algoritma yang dapat digunakan untuk melakukan pemodelan statistik non linear dan memberikan alternatif baru untuk regresi logistik (Tu, 1996). MLP tidak terpengaruh dengan adanya multikolinieritas. Multikolinieritas adalah kondisi dimana antar variabel bebas memiliki korelasi yang cukup tinggi. Metode ini dikombinasikan dengan MC untuk menghasilkan prediksi perubahan penggunaan lahan di masa depan. Prinsip dasar MC dalam mengukur probabilitas serangkaian kejadian di masa sekarang untuk memprediksi kejadian di masa depan menunjukkan sifat kebergantungan dalam MC, sehingga dapat dimanfaatkan untuk penyusunan model simulasi termasuk perubahan penggunaan lahan.

Permasalahan penelitian dapat dirumuskan sebagai berikut:

1. Perubahan penggunaan lahan dapat mengakibatkan perubahan kondisi alami, yang akhirnya menyebabkan terjadinya perubahan lingkungan. Informasi penggunaan lahan pada masa lalu, saat ini dan masa depan merupakan informasi penting dan perlu dipantau. Pemanfaatan citra satelit penginderaan jauh resolusi menengah multitemporal untuk memperoleh informasi penggunaan lahan multiwaktu perlu diteliti. Perubahan penggunaan lahan dalam suatu periode waktu tertentu perlu diteliti sebagai dasar dalam memprediksi penggunaan lahan di masa depan.
2. Pemodelan perubahan penggunaan lahan dengan pendekatan top-down dapat dilakukan dengan memanfaatkan citra satelit penginderaan jauh resolusi menengah. Informasi penggunaan lahan hasil ekstraksi dari citra satelit penginderaan jauh digunakan sebagai input dalam pemodelan. Pemodelan perubahan penggunaan lahan (variabel terikat) dengan mempertimbangkan faktor-faktor yang mempengaruhinya (variabel bebas) selama ini dikembangkan dengan model berbasis pola yang dikombinasikan dengan metode statistik konvensional untuk meningkatkan akurasinya. MLP memiliki kemampuan untuk mencari hubungan antara faktor-faktor yang mempengaruhi terhadap perubahan penggunaan lahan. MLP mampu mengatasi kompleksitas variabel bebas yang bersifat non linear dan tidak terpengaruh multikolinieritas. Sementara itu MC memiliki kemampuan mengukur probabilitas dari perubahan penggunaan lahan di masa sekarang untuk memprediksi penggunaan lahan di masa depan Oleh karena itu pemodelan perubahan penggunaan lahan berbasis citra satelit resolusi menengah dengan menggunakan metode MLP dan MC perlu dikaji tingkat akurasinya.

Atas dasar perumusan masalah tersebut di atas maka penulis akan melakukan penelitian dengan judul : Kajian Perubahan Penggunaan Lahan Berbasis Citra Satelit

Penginderaan Jauh Resolusi Menengah Dengan Metode Multilayer Perceptron Dan Markov Chain Di Sebagian Kabupaten Bantul

Penelitian ini bertujuan untuk mengkaji kemampuan citra satelit penginderaan jauh resolusi menengah Landsat untuk ekstraksi informasi penggunaan lahan tahun 2002, 2009 dan 2013 di sebagian Kabupaten Bantul.

Perubahan Penggunaan Lahan Tahun 2002-2009

Perubahan penggunaan lahan dilakukan dengan membandingkan penggunaan lahan dalam jangka waktu tertentu. Pada penelitian ini perubahan penggunaan lahan yang akan diteliti adalah perubahan penggunaan lahan antara tahun 2002 dan 2009. Sama sekali tidak terjadi perubahan penggunaan lahan sungai. Total luas keempat penggunaan lahan yang tidak mengalami perubahan (bertahan) seluas 19.485,45 ha (ditunjukkan pada diagonal matriks). Total 1 merupakan luas penggunaan lahan pada waktu t1 (tahun 2002) dan Total 2 merupakan luas penggunaan lahan pada waktu t2 (tahun 2009). Perubahan penggunaan lahan dari lahan pertanian menjadi permukiman seluas 2.766,78 ha dan dari hutan dan kebun campuran menjadi permukiman seluas 804,69 ha. Perubahan penggunaan lahan dari permukiman menjadi lahan pertanian dan hutan dan kebun campuran seharusnya tidak terjadi namun pada hasil pengolahan ini terjadi seluas 334,26 ha dan 25,74 ha. Hal ini dimungkinkan terjadi karena pada rentang tahun antara 2002 dan 2009 wilayah penelitian mengalami gempa pada tahun 2006 sehingga berakibat banyaknya pemukiman yang hancur. Sebagian besar bangunan yang rusak dibangun kembali namun ada juga yang tidak sehingga menjadi lahan terbuka. Pengaruh kesalahan dalam klasifikasi juga memberi kontribusi dalam hal ini. Pengaruh tutupan lahan dalam periode waktu yang berbeda memungkinkan tutupan bangunan (permukiman) dilingkupi tutupan lahan vegetasi sehingga dimasukkan ke dalam kelas lahan pertanian atau hutan dan kebun campuran. Sesuai matriks Tabel 4.5 menunjukkan berkurangnya luas penggunaan lahan permukiman pada tahun 2002 sebesar 360ha. Penggunaan lahan lahan pertanian berkurang seluas 2.766,78 ha dan penggunaan lahan hutan dan kebun campuran berkurang seluas 804,69 ha. Pada tahun 2009 terjadi penambahan luas (terhadap luas penggunaan lahan yang tidak mengalami perubahan/bertahan) berupa penggunaan lahan permukiman seluas 3.571,47 ha (pada Total perubahan bersih (*net change*) antara tahun 2002 dan 2009 untuk penggunaan lahan pemukiman bertambah sebesar 3.211,47 ha dan lahan pertanian berkurang sebesar 2.432,52 ha serta hutan dan kebun campuran seluas 778,95 ha.

Perubahan penggunaan lahan dari lahan pertanian menjadi permukiman terbesar terjadi di Kecamatan Banguntapan (717,97 ha) dimana sebagian besar wilayahnya berada di pinggiran kota Yogyakarta. Selain itu perubahan yang cukup besar juga terjadi di Kecamatan Sewon, Kasihan, Jetis dan Bantul. Hal ini wajar terjadi mengingat lokasi Kecamatan Banguntapan, Sewon dan Kasihan yang berbatasan langsung dengan wilayah Kota Yogyakarta. Sehingga pertumbuhan permukiman meluber ke daerah pinggiran Kota Yogyakarta. Kecamatan Bantul juga mengalami perubahan penggunaan lahan ke permukiman yang cukup besar sebagai ibukota Kabupaten Bantul yang semakin berkembang. Perubahan penggunaan lahan dari hutan dan kebun campuran ke permukiman terjadi cukup besar pada Kecamatan Kasihan (211,55 ha) dan Imogiri (361,02ha). Kecamatan Kasihan berbatasan langsung dengan Kota Yogyakarta dan meskipun memiliki topografi berbukit pertumbuhan permukiman di wilayah tersebut relatif besar. Kecamatan Imogiri memiliki penggunaan lahan hutan dan kebun campuran yang luas cukup wajar bila terjadi perubahan yang terbesar dibanding kecamatan lainnya.

Pemodelan Perubahan Penggunaan Lahan

Tahap pemodelan perubahan penggunaan lahan terdiri atas Tahap Potensial Transisi (*Transition Potentials*) yaitu tahap untuk menentukan lokasi yang berpotensi untuk mengalami perubahan, Tahap Area Transisi yaitu tahap untuk menentukan besar luasan yang mengalami perubahan, Tahap Prediksi Perubahan Penggunaan Lahan *(Change Prediction*) yaitu tahap menentukan hasil prediksi berdasar pada hasil dari dua tahap sebelumnya tersebut dan Tahap Validasi yaitu tahap uji akurasi hasil prediksi. Untuk keperluan prediksi penggunaan lahan pada suatu tahun diperlukan penentuan lokasi yang berpotensi mengalami perubahan dan besar perubahan yang akan terjadi. Oleh karena itu tahap pertama dan kedua diperlukan untuk proses pada tahap ketiga. Berdasar Peta Perubahan Penggunaan Lahan Tahun 2002-2009 menunjukkan perubahan yang logis mungkin terjadi adalah perubahan dari lahan pertanian dan hutan dan kebun campuran menjadi permukiman. Kelas perubahan inilah yang akan dimodelkan pada penelitian ini.

Tahap Potensial Transisi

Untuk menentukan lokasi yang berpotensi untuk mengalami perubahan, ditentukan kelas perubahan penggunaan lahan yang akan dimodelkan. Pada penelitian ini untuk keperluan pemodelan maka perubahan penggunaan lahan yang akan dimodelkan adalah perubahan dari lahan pertanian dan hutan dan kebun campuran menjadi permukiman. Untuk menentukan lokasi yang berpotensi mengalami perubahan diperlukan masukan faktor yang memungkinkan berpengaruh terhadap terjadinya perubahan. Dalam penelitian ini varibel perubahan dipilih berdasar pada dugaan awal (a priori) dengan berdasar pada pengetahuan lokal terhadap daerah kajian serta pertimbangan dari berbagai studi literatur. Faktor-faktor tersebut selanjutnya disebut sebagai variabel perubahan. Variabel ini meliputi variabel yang bersifat memacu terjadinya perubahan maupun yang bersifat menghambat. Variabel perubahan yang digunakan dalam penelitian ini meliputi kepadatan jaringan jalan, jarak terhadap jalan, kemiringan lereng dan jarak terhadap sungai. Selain itu juga digunakan Peta perubahan penggunaan lahan ke permukiman sebagai nilai kemungkinan terjadinya perubahan dari penggunaan selain permukiman menjadi kelas permukiman.

Selain dengan perhitungan sederhana kepadatan garis (*line density*), perhitungan kepadatan garis dapat dianalisis menggunakan sistem kernel (kernel density). Kernel density menghitung kepadatan suatu objek garis dalam suatu area ketetanggaan di sekitar objek garis tersebut. Kernel density membentuk suatu kurva permukaan mulus *(smooth)* yang dibangun terhadap suatu objek berbentuk garis pada jarak tertentu. Semakin menjauhi garis nilai kepadatan semakin kecil dan mencapai nol pada batas akhir radiusnya. Nilai kepadatan sel/grid dihitung dari nilai permukaan kernel yang bertumpang tindih dengan sel/grid tersebut.

Penelitian ini menyusun variabel perubahan berupa peta kepadatan jaringan jalan dengan menggunakan perangkat lunak ArcGIS 10. Tool yang digunakan adalah *kernel density*. Mengingat perhitungan kepadatan mengacu pada satuan ukuran jarak dan luas maka perlu diperhatikan sistem koordinat peta yang digunakan. Sistem koordinat peta yang digunakan dalam penelitian ini adalah *Universal Transverse Mercator* (UTM) dengan satuan ukuran meter. Ukuran sel/grid yang dihasilkan adalah 30 x 30 m menyesuaikan resolusi spasial citra satelit yang digunakan dalam pemodelan. Sedangkan radius yang digunakan adalah 500 m dengan asumsi bahwa kepadatan nilai kepadatan memiliki satuan jarak per luasan misal meter per meter persegi (m/m^2). Untuk kepadatan jaringan jalan yang bersumber dari peta RBI, maka jaringan jalan yang digunakan adalah kelas jalan nasional, provinsi, lokal dan lainnya digabung menjadi satu. Hal ini mempertimbangkan bahwa kepadatan dianalisis berdasar keberadaan jalan yaitu ada tidaknya jalan pada suatu lokasi tanpa mempertimbangkan kelas jalan. Proses analisis kepadatan jaringan jalan sebagaimana . Simbolisasi kepadatan menggunakan gradasi warna mengingat data kepadatan berupa data kontinyu. Semakin banyak jaringan jalan yang terdapat di sekitar suatu sel maka nilai sel tersebut semakin tinggi disimbolkan dengan warna merah dan semakin jarang jaringan jalan yang terdapat di sekitar suatu sel atau bahkan tidak ada maka nilai sel tersebut semakin rendah disimbolkan dengan warna semakin hijau.

Perhitungan jarak dapat dianalisis melalui perhitungan jarak lurus dari objek (*euclidean distance). Euclidean distance* antara dua titik yang memiliki koordinat (x,y) dan (a,b) dapat dihitung dengan formula:

$$dist((x, y), (a, b)) = \sqrt{(x - a)^2 + (y - b)^2}$$

Formula ini mengacu pada *teorema pythagoras. Euclidean distance* pada data raster dihitung dari pusat sel sumber ke pusat dari masing-masing sel-sel di sekitarnya. Perhitungan jarak adalah menggunakan jarak terpendek dengan pusat sel sumber. Perhitungan *euclidean distance* merupakan perhitungan jarak sebenarnya dari suatu pusat sel ke sel lainnya. Perhitungan jarak selain menggunakan jarak sebenarnya juga dapat memperhitungkan jarak berdasar biaya perjalanan yaitu dengan perhitungan *cost distance.* Fungsi jarak pada cost distance tidak berdasar pada satuan unit geografis melainkan berdasar atas satuan biaya. Oleh karena itu perlu disusun peta unit biaya (*cost raster)* untuk melakukan perhitungan *cost distance. Cost raster* merupakan suatu peta satuan unit biaya yang didasarkan pada analisa kondisi wilayah. *Cost raster* dibuat dengan menggunakan peta penggunaan lahan dan kemiringan lereng. Hal ini berdasar atas pertimbangan bahwa dalam pembangunan jalan sangat dipengaruhi oleh faktor kemiringan lereng dan penggunaan lahan terkait dalam hal biaya. Mengingat perhitungan jarak terhadap jalan akan digunakan dalam pemodelan perubahan penggunaan lahan dan mengikutsertakan faktor kemiringan lereng juga maka perhitungan cost distance tidak digunakan.

Simbolisasi jarak terhadap jalan menggunakan gradasi warna mengingat data berupa data kontinyu. Makin jauh terhadap jaringan jalan yang terdapat di sekitar suatu sel maka nilai sel tersebut semakin tinggi disimbolkan dengan warna merah dan semakin dekat dengan jaringan jalan yang terdapat di sekitar suatu sel atau bahkan tidak ada maka nilai sel tersebut makin rendah disimbolkan dengan warna makin hijau.

Penelitian ini menyusun variabel perubahan berupa peta kemiringan lereng dengan menggunakan perangkat lunak ArcGIS 10. Ukuran sel/grid yang dihasilkan adalah 30 x 30 m menyesuaikan resolusi spasial citra satelit yang digunakan dalam pemodelan. Kemiringan lereng dihasilkan dari kontur Peta Rupa Bumi Indonesia skala 1 : 25.000 tahun 2000. Semakin rapat interval antar garis kontur maka semakin besar perbedaan ketinggian yang berarti semakin curam kemiringan lerengnya. Mengingat data kontur berupa data diskret untuk itu perlu dilakukan perubahan menjadi data kontinyu. Proses yang dilakukan antara lain dengan melakukan interpolasi dari kontur yang ada dengan menggunakan *Triangular Irregular Network (*TIN) untuk membentuk permukaan ketinggian. TIN membentuk permukaan ketinggian dengan jaring-jaring segitiga dengan mengacu pada algoritma triangulasi delauny. Untuk memperoleh hasil interpolasi yang baik maka proses interpolasi dilakukan dengan menggunakan area yang lebih luas daripada lokasi penelitian. Hal ini dikarenakan semakin banyak data yang digunakan maka proses interpolasi semakin baik. Jadi pemotongan wilayah berdasar lokasi penelitian dilakukan setelah perhitungan kemiringan lereng dilakukan. Permukaan ketinggian yang dihasilkan berbentuk vektor sehingga perlu dikonversi ke data raster. Selanjutnya dilakukan perhitungan kemiringan lereng (*slope*). Simbolisasi kemiringan lereng menggunakan gradasi warna mengingat data kemiringan lereng berupa data kontinyu. Semakin tinggi nilai kemiringan lereng (semakin curam) yang terdapat di sekitar suatu sel maka nilai sel tersebut semakin tinggi disimbolkan dengan warna merah dan semakin rendah disimbolkan dengan warna semakin hijau.

Sebelum digunakan sebagai input, masing-masing variabel dinormalisasikan. Semua variabel dinormalisasi ke dalam rentang nilai 0-1 dimana semakin besar nilai piksel maka semakin mendekati nilai 1. Mengingat MLP mampu melakukan proses regresi terhadap variabel yang bersifat non linear maka normalisasi tidak perlu disesuaikan berdasarkan pengaruh variabel terhadap perubahan. Sebagai contoh variabel kepadatan jaringgan jalan dinormalisasi menjadi bernilai 0-1, semakin kecil kepadatan jaringan jalan maka nilainya mendekati 0. Variabel jarak terhadap jalan dinormalisasi menjadi bernilai 0-1, semakin jauh jarak dari jalan maka nilainya mendekati 0. Variabel kemiringan lereng dinormalisasi menjadi bernilai 0-1, semakin besar kemiringan lereng maka nilainya mendekati 0. Variabel jarak terhadap sungai dinormalisasi menjadi bernilai 0-1, semakin dekat jarak dengan sungai maka nilainya mendekati 0. Hal itu tidak perlu dilakukan karena MLP akan mampu mencari hubungan antara keempat variabel tersebut tanpa diketahui sebelumnya hubungan antara variabel-variabel tersebut.

Masing-masing variabel independent selanjutnya diuji dengan menggunakan variable Cramer's test V untuk mengetahui keterkaitan antara variabel dengan kelas penggunaan lahan. Rumus Cramer's test V adalah :V = SQRT(x2 / (n (k - 1))). Hasil uji keterkaitan menghasilkan Overall V = 0.3709 untuk variabel kepadatan jalan, 0,2978 untuk variabel jarak terhadap jalan, 0,4683 untuk variabel kemiringan lereng, 0,2528 untuk variabel jarak terhadap sungai dan 0,6479 untuk hasil transformasi evidence likelihood. Jarak terhadap sungai memiliki nilai terkecil yang berarti keterkaitan variabel tersebut terhadap perubahan kelas penggunaan lahan relatif kecil.

Selanjutnya adalah menjalankan sub-model dengan menggunakan metode *Multilayer Perceptron* (MLP) dengan fungsi regresi. MLP menggunakan algoritma *back propagation* dengan fungsi aktivasi non linear yaitu *sigmoid function*. Struktur MLP terdiri atas 1 node pada input layer untuk setiap variabel masukan, 1 node hidden layer dan 2 node output layer (dimana 1 node mengidentifikasi potensi untuk berubah/ transition dan 1 node mengidentifikasi kebertahanan/persistence). Jumlah *hidden layer* adalah bilangan bulat dari akar kuadrat antara jumlah input dan output sehingga jumlahnya tergantung jumlah variabel input dan output dalam model. Jadi terdapat 5 input dalam sub-model MLP antara lain : kepadatan jaringan jalan, jarak terhadap jalan, kemiringan lereng dan jarak terhadap sungai dan hasil transformasi *evidence likelihood* permukiman sebagai variabel independent (5 node pada input layer) dan peta potensial perubahan penggunaan lahan ke permukiman sebagai variabel dependent (4 node pada output layer).

Pelatihan jaringan menggunakan peta hasil *cross tabulation* antara penggunaan lahan tahun 2002 dan 2009. Peta Transition (transisi dari hutan dan kebun campuran dan lahan pertanian ke permukiman dan Peta *Persistence* merupakan peta kebertahanan dari hutan dan kebun campuran dan lahan pertanian yang tidak mengalami perubahan. Jumlah sampel menggunakan jumlah piksel kelas penggunaan lahan yang mengalami perubahan terkecil yaitu sebesar 8941 piksel (kelas hutan dan kebun campuran menjadi permukiman). Setengah dari jumlah tersebut digunakan untuk proses pelatihan dan setengahnya lagi untuk pengujian.

Adapun parameter MLP yang digunakan antara lain menggunakan *learning rate* antara 0.001, *momentum factor* 0.5, *sigmoid constanta* 1 dan iteration 10000. Pada proses simulasi dilakukan berulang kali dengan mengubah *learning rate* dan jumlah iterasi atas pertimbangan dari berbagai penelitian kedua parameter ini cukup signifikan berpengaruh terhadap hasil RMS eror. Semakin kecil nilai RMSeror maka semakin besar nilai *accuracy rate*. Berdasar proses MLP menggunakan semua variabel perubahan dihasilkan accuracy rate MLP sebesar 73,44%.

Selanjutnya Output yang dihasilkan dari model ini adalah Peta Potensi Perubahan (Peta *Potential Transition*/PPT) yang memiliki nilai peluang antara 0-1, dimana semakin mendekati 1 maka lokasi tersebut memiliki peluang yang tinggi untuk berubah menjadi penggunaan lahan lain sebagaimana 0. PPT ini meliputi perubahan dari kelas yang dimodelkan yaitu dari lahan pertanian ke permukiman dan dari hutan dan kebun campuran ke permukiman. PPT dari lahan pertanian ke permukiman sebesar 0 - 94 dan dari hutan dan kebun campuran ke permukiman sebesar 0 – 0,95.

Analisis Perubahan Penggunaan Lahan

Perubahan penggunaan lahan di sebagian Kabupaten Bantul antara tahun 2002-2009 dan 2009-2013 adalah perubahan penggunaan kelas permukiman menunjukkan perubahan yang cukup signifikan. Periode tahun 2002-2009 terjadi penambahan permukiman seluas 3.571,47 ha dan pada tahun 2009-2013 seluas 1.932,75 ha. Hal ini menunjukkan bahwa pertumbuhan permukiman tahun 2009-2013 (4 tahun) hampir sebanding dibandingkan periode 2002-2009 (7 tahun).

Pola pertumbuhan permukiman dalam dua periode tersebut perlu dikaitkan dengan variabel perubahan penggunaan lahan guna mengetahui hubungan diantaranya. Adapun rata-rata (mean) masing-masing variabel menunjukkan bahwa nilai rata-rata tersebut tidak menunjukkan bahwa pertumbuhan permukiman rata-rata terjadi pada nilai tersebut. Nilai tersebut hanya menunjukkan rata-rata sebaran berdasarkan rentang nilai variabel. Pola hubungan variabel kepadatan jaringan jalan terhadap pertumbuhan permukiman. Meskipun rentang tahun yang berbeda namun dari grafik tersebut menunjukkan pola hubungan yang sama. Pertumbuhan permukiman di sebagian Kabupaten Bantul ini sebagian besar terjadi pada area dengan kepadatan jaringan jalan antara 10–15 m/km2. Semakin besar kepadatan jaringan jalan, pertumbuhan permukiman semakin kecil. Hal ini kemungkinan dipengaruhi oleh keberadaan permukiman yang cukup padat pada area dengan kepadatan jaringan jalan yang tinggi sehingga bertambahnya permukiman sangat sedikit terjadi karena keterbatasan lahan yang tersedia.

Hubungan pertumbuhan permukiman dengan jarak terhadap jalan dan kemiringan lereng menunjukkan pola yang serupa. Semakin dekat dengan jalan pertumbuhan permukiman semakin besar. Semakin kecil kemiringan lereng pertumbuhan permukiman semakin besar. Pada dua periode menunjukkan pola yang sama. Hal ini menunjukkan bahwa kedua variabel tersebut sesuai digunakan untuk pemodelan perubahan penggunaan lahan permukiman karena memiliki hubungan yang sesuai dugaan awal dan menunjukkan pola yang cukup signifikan.

Kesimpulan

Hasil klasifikasi terselia citra satelit penginderaan jauh resolusi menengah Landsat menggunakan metode maksimum *likelihood* memiliki akurasi klasifikasi penggunaan lahan pada tahun 2002 sebesar 93,4095%, pada tahun 2009 sebesar 94,4272% dan pada tahun 2013 sebesar 95,5582%.

Penggunaan lahan di sebagian Kabupaten Bantul antara tahun 2002-2009 mengalami perubahan dari lahan pertanian menjadi permukiman seluas 2.766,78 ha dengan perubahan terluas terjadi di Kecamatan Banguntapan seluas 717,97 ha (25,21%). Perubahan kelas penggunaan lahan hutan dan kebun campuran ke permukiman seluas 804,69 ha dimana perubahan terluas terjadi di Kecamatan Imogiri seluas 361,02 ha (6,63%). Sehingga pada periode tahun 2002-2009 terjadi penambahan permukiman seluas 3.571,47 ha. Pertumbuhan permukiman di sebagian Kabupaten Bantul periode 2002-2009 kaitannya dengan variabel perubahan penggunaan lahan menunjukkan pola dimana variabel perubahan berupa kepadatan jaringan jalan, jarak terhadap jalan dan kemiringan lereng lebih berpengaruh terhadap terjadinya pertumbuhan permukiman dibandingkan variabel jarak terhadap sungai.

Pada pemodelan perubahan penggunaan lahan 2013 dengan menggunakan kombinasi MLP dan MC dihasilkan akurasi hasil prediksi terbaik dengan *overall accuracy* 86,16 % dan Kappa sebesar 0,79 *(substantial agreement),* sehingga model dapat diaplikasikan untuk prediksi penggunaan lahan pada tahun-tahun yang akan datang.

Pemodelan Spasial Perubahan Pertanian Lahan Kering dalam Kaitannya terhadap Besaran Erosi di Daerah Aliran Sungai (DAS) Ci Sokan

Spatial Modeling of Dryland Farming Conversion Related to the Amount of Erosion in the Ci Sokan Watershed

Nama	: Eri Khaeruman Khuluki
NIP	: 198108112008041001
Instansi	: BPN
Tahun Intake	: 2013
Tingkat Beasiswa	: Master Local
Program Studi	: Magister Ilmu Geografi
Negara Studi	: Indonesia
Universitas	: Universitas Indonesia

ABSTRAK

Lahan kering merupakan sumberdaya pertanian terbesar ditinjau dari segi luasnya. Profil usaha tani pada agroekosistem ini sebagian masih diwarnai oleh rendahnya produktifitas lahan. Daerah Aliran (DA) Ci Sokan merupakan salah satu dari Sub DA Ci Tarum yang memiliki sebaran pertanian lahan kering cukup luas yang dikhawatirkan berdampak pada besarnya erosi dan berakhir pada pembentukan lahan kritis. Penelitian ini bertujuan untuk mengkaji dan menilai persebaran spasial perubahan pertanian lahan kering di DA Ci Sokan yang diduga sebagai salah satu kontributor yang menyebabkan gangguan fisik tanah dan degradasi lahan oleh erosi. Hasil penelitian menunjukan bahwa pertanian lahan kering di DA Ci Sokan sejak tahun 1990 sampai 2010 semakin bertambah. Secara spasial peningkatan luas pertanian lahan kering terjadi pada daerah yang memiliki ketinggian antara 700-1000 mdpl dan kelas lereng agak curam (15-25%) dan curam (25-40%). Dengan pemodelan spasial menggunakan metode *Artificial Neural Network* (ANN) dan *Markov Chain* diprediksi terdapat penambahan luas pertanian lahan kering pada tahun 2030 sebesar 16,5% dari tahun 2015. Dari penelitian ini pula diketahui bahwa Tingkat Bahaya Erosi (TBE) kelas sedang sampai dengan sangat berat semakin bertambah seiring dengan meningkatnya jumlah pertanian lahan kering di DA Ci Sokan.

Kata Kunci: Pemodelan spasial, pertanian lahan kering, erosi, *Artificial Neural Network, Markov Chain*

ABSTRACT

Dryland farming should contribute significant amount of agricultural product, based on its extent area. However, some of this agro-ecosystems practice has low productivities. Ci Sokan watershed is one of the sub-watersheds of Ci Tarum River, which has vast area of dryland farming, and has been considered affects the amount of erosion and causes degraded land. This research aims to study the spatial distribution of the change of dryland farming area in Ci Sokan watershed, which is supposed to contribute to soil physical disturbance and land degradation caused by erosion. The results show that from 1990 to 2010, the area of dryland farming in Ci Sokan watershed increased. The model predicted that the conversion will mostly occurred in the area with the height of 700-1000 m above sea level and intermediate to steep slope (15-25% and 25-40%). Using spatial modelling with Artificial Neural Network (ANN) and Markov Chain method, the predicted show that dryland farming area will increase 16.5% by 2030, compare to the area in 2015. The results also show that the research area is in the intermediate to highly risk of Erosion Hazard Level, which is related to the increasing of shifting land use into dryland farming.

Keywords: Spatial modeling, dryland farming, erosion, Artificial Neural Network,

Tegalan sebagai salah satu bentuk pertanian lahan kering pada umumnya kurang baik konservasi tanahnya dan menyumbang muatan sedimen dalam proporsi yang besar. Tidak seperti lahan sawah yang dapat berfungsi sebagai filter sedimen, lahan tegalan justru seringkali berperan sebagai penghasil sedimen karena erosi. Hasil pengukuran di berbagai tempat menunjukan bahwa pada penggunaan lahan tegalan tanpa disertai konservasi tanah, besarnya erosi yang terjadi >40 ton/ha/tahun (Sukmana, 1995). Erosi bukan hanya mengangkut lapisan tanah, namun juga mengangkut hara dan bahan organik, baik yang terkandung di dalam tanah maupun yang berupa input pertanian.

Perubahan penggunaan lahan khususnya pertanian lahan kering di DA Ci Tarum diduga menyebabkan gangguan fisik tanah dan degradasi lahan oleh erosi. Salah satu Sub DA Ci Tarum yang mengalami fenomena tersebut adalah Daerah Aliran (DA) Ci Sokan. Dari hasil penelitian sebelumnya yang dilakukan oleh Sinukaban (1992) pada sembilan desa di DA Ci Sokan, memiliki laju erosi berkisar antara 44-480 ton/ha/thn. Laju erosi tersebut merupakan laju erosi yang cukup tinggi yang dapat mendukung terjadinya degradasi lahan dan berakhir pada pembentukan lahan kritis. Lebih jauh dikatakan bahwa lahan kritis di DA Ci Sokan sampai tahun 2012 mencapai 46.100 ha atau 37,7 % dari luas DA. Hasil penelitian lainnya yang dilakukan oleh Kusratmoko et al (2002) ditinjau dari rata- rata nilai persentase luas wilayah potensi erosi tinggi dan sangat tinggi di DA Ci Tarum, maka DA Ci Sokan merupakan daerah aliran sungai yang paling tinggi tingkat bahaya erosinya yaitu mencapai 49%.

Peningkatan laju erosi di DA Ci Sokan secara langsung akan mempengaruhi sedimentasi yang terjadi di Waduk Cirata sehingga mengakibatkan terjadinya pendangkalan waduk. Fungsi Waduk Cirata sangat strategis dalam berbagai hal diantaranya digunakan sebagai sumber air baku, irigasi pertanian, perikanan, dan pembangkit tenaga listrik. Dalam konteks perlindungan wadukdariprosessedimentasi dikatakan bahwa penanggulangan bahaya erosi di DA Ci Sokan perlu mendapatkan perhatian lebih (Kusratmoko et al., 2002). Permasalahan erosi dan sedimentasi di Waduk Cirata menunjukan trend yang terus meningkat setiap tahunnya. Hingga tahun 2000, sedimen di dasar Waduk Cirata sudah mencapai 62,8 juta m^3, sedangkan batas ekstrim yang dirancang bagi endapan di waduk tersebut volumenya sebesar 79,3 m^3. Tingginya laju sedimentasi aktual yang rata-rata mencapai 7,30 juta m^3/tahun melampaui asumsi desain yang hanya 5,67 juta m^3/tahun menyebabkan umur PLTA pada daerah tersebut yang diperkirakan usianya mencapai 60 tahun menurun hanya sampai 36 tahun (Gultom, 2012).

Fenomena perubahan pertanian lahan kering berupa tegalan akan berakibat negatif terhadap kualitas lahan melalui besarnya erosi yang dihasilkan. Tingginya erosi lambat laun dapat menyebabkan lahan menjadi kritis, serta berpengaruh kurang baik terhadap kualitas perairan sungai yang menyebabkan tingginya proses sedimentasi. Kedua hal tersebut tampaknya terjadi di DA Ci Sokan. Untuk itulah penelusuran secara geografis terhadap perubahan pertanian lahan kering dan besaran laju erosi, menjadi penting untuk dilakukan. Penelusuran/penelitian secara geografis ini dengan judul "Pemodelan Spasial Perubahan Pertanian Lahan Kering dalam Kaitannya Terhadap Besaran Erosi di Daerah Aliran (DA) Ci Sokan."

Alih fungsi lahan pertanian ke non pertanian mengakibatkan pertanian di DA Ci Sokan terdesak untuk memanfaatkan lahan kering di perbukitan yang kurang produktif untuk usaha tanaman pangan. Permasalahan utama pertanian lahan kering yakni (1) tingginya laju erosi, (2) kesuburan tanah rendah, (3) ketersediaan air terbatas karena tergantung dari curah hujan (Kelompok Penelitian Agro Ekosistem, 1989). Kesalahan teknik pendayagunaan pertanian lahan kering di DA ini akan banyak menimbulkan dampak negatif, tidak hanya pada kawasan yang bersangkutan juga terhadap kawasan dibawahnya yaitu berupa timbulnya lahan kritis, penurunan produktivitas lahan, dan sedimentasi. Pendayagunaan pertanian lahan kering memberikan dampak yang luas tidak hanya bagi perekonomian petani maupun masyarakat umumnya di luar sektor pertanian juga terhadap tata air dan lingkungan.

Perubahan dan pemanfaatan pertanian lahan kering di DA Ci Sokan menimbulkan dampak negatif. Apabila pola perubahan pertanian lahan kering yang telah berlangsung selama ini dimodelkan secara dinamik dan berbasis spasial, maka akan diperoleh informasi tentang lokasi (*where*), luas (*how much*) perubahan penggunaan lahan yang berpotensi menimbulkan penurunan kualitas lahan. Dengan demikian, antisipasi pencegahan terhadap penurunan kualitas lahan dapat dilakukan dengan tepat, sesuai dengan permasalahan yang akan terjadi. Berdasarkan dengan latar belakang yang telah diuraikan, maka permasalahan pokok yang menjadi pertanyaan dalam penelitian ini adalah :

1. Bagaimanakah perubahan sebaran pertanian lahan kering di Daerah Aliran Ci Sokan 1990-2010?
2. Bagaimanakah prediksi sebaran pertanian lahan kering Daerah Aliran Ci Sokan pada tahun 2030?
3. Bagaimanakah persebaran erosi yang terjadi akibat perubahan pertanian lahan kering di Daerah Aliran Ci Sokan 1990-2030?

Tujuan dari penelitian ini adalah untuk mengkaji dan menilai persebaran spasial perubahan pertanian lahan kering di Daerah Aliran (DA) Ci Sokan yang diduga sebagai salah satu kontributor yang menyebabkan gangguan fisik tanah dan degradasi lahan oleh erosi. Secara umum manfaat yang diharapkan dari penelitian ini adalah dapat memberikan gambaran mengenai perubahan pertanian lahan kering di DA Ci Sokan serta proyeksinya dimasa mendatang sehingga hasil penelitian dapat dijadikan sebagai salah satu bahan pertimbangan dalam perencanaan penggunaan lahan untuk meminimalkan penurunan kualitas lahan.

Penggunaan Lahan Tahun 1990, 2000, dan 2010

Data penggunaan lahan DA Ci Sokan diperoleh melalui analisis Citra Landsat tahun 1990-2010 menggunakan klasifikasi terbimbing. Berdasarkan analisis citra tersebut, DA Ci Sokan memiliki 9 kelas penggunaan lahan yaitu hutan, kebun campuran, perkebunan, permukiman, sawah, semak belukar, situ/danau/telaga, tanah terbuka, dan tegalan. Penggunaan lahan sawah mendominasi penggunaan lahan, baik pada tahun 1990, 2000 dan 2010, dengan proporsi sekitar 33% dari luas DAS. Secara spasial penggunaan lahan sawah menyebar di bagian tengah sampai utara DAS Ci Sokan. Sawah merupakan sumber penghasilan utama bagi petani, terutama di Kecamatan Karang Tengah, Cibeber, dan Cilaku Kabupaten Cianjur. Produksi padi sawah pada ketiga kecamatan ini > 36 ton/ha pada tahun 2013 (BPS, 2014).

Kebun Campuran berada pada urutan kedua dengan proporsi luas sekitar 25% dari luas DA. Sebagian besar Kebun Campuran dijumpai di Kecamatan Bojongpicung, Haurwangi, dan Rongga. Dominasi penggunaan lahan selanjutnya adalah hutan dengan proporsi sekitar 16% dari luas DA. Penggunaan lahan hutan umumnya tersebar di daerah puncak Gunung Gede, Gunung Buleud dan Gunung Masigit. Dalam kurun waktu 20 tahun persentase luas lahan hutan di DA Ci Sokan menurun dari 20,6% tahun 1990 menjadi 15,4% tahun 2010 .

Pertanian lahan kering semusim, dalam hal ini adalah tegalan pada tahun 2010 menduduki posisi ke empat terluas dengan proporsi sekitar 11% dari luas DA. Jenis tanaman yang diusahakan pada lahan tegalan berupa tanaman semusim seperti kentang, bawang daun, wortel, dan petsai/sawi. Usaha tanaman semusim tersebut dilakukan secara intensif karena memiliki nilai ekonomis yang cukup tinggi. Tegalan menyebar terutama di Kecamatan Pacet dan Cugeunang. Kedua kecamatan tersebut merupakan salah satu sentra produksi sayuran unggulan di Jawa Barat.

Penggunaan lahan dengan proporsi luasan terbesar lainnya secara berturut-turut adalah perkebunan, permukiman, semak belukar, situ/danau/telaga. Tanah Terbuka merupakan penggunaan lahan yang luasnya paling kecil dengan proporsi sekitar 0.06% dari luas DA. Tidak adanya perubahan urutan penggunaan lahan dari tahun 1990 sampai 2010, namun terdapat perbedaan masing-masing luasan penggunaan lahan seperti halnya luas hutan yang semakin berkurang, sedangkan pertanian lahan kering seperti tegalan memiliki kecenderungan yang terus meningkat. Hal ini menunjukan bahwa telah terjadi perubahan penggunaan lahan yang relatif cepat. Apabila perubahan penggunaan lahan ini tidak sesuai dengan daya dukung lahannya, hal ini akan memberikan pengaruh terhadap kelestarian dan produktivitas seumberdaya lahan, baik sebagai areal pertanian maupun yang berkaitan dengan fungsi hirologis DA Ci Sokan.

Perubahan Pertanian Lahan Kering

Berdasar kriteria kesesuaian lahan menurut Pusat Penelitian Tanah Tahun 1983, lahan kelerengan >15% dan ketinggian di atas 750 mdpl termasuk kriteria tidak sesuai (N) untuk tanaman pangan lahan kering. Berdasar hal tersebut sekitar 70% penggunaan pertanian lahan kering DA Ci Sokan pada 2030 tak sesuai dengan kemampuan lahannya. Peningkatan luas tegalan banyak terjadi di Kecamatan Campaka, Cibeber, Gununghalu, dan Rongga. Dengan demikian peningkatan tegalan pada kecamatan ini perlu diwaspadai karena selain tidak sesuai dengan kesesuaian lahannya penggunaan lahan tegalan merupakan salah satu faktor yang mendorong terjadinya erosi yang dapat memicu tingginya muatan sedimen yang diendapkan di Waduk Cirata.

Selain tegalan, jenis penggunaan lahan yang mengalami peningkatan pada periode 1990-2000 dan 2000-2010 adalah permukiman. Permukiman mengalami peningkatan luas area yang cukup signifikan setiap periodenya. Meningkatnya penggunaan lahan permukiman merupakan dampak dari semakin banyaknya jumlah penduduk di DA Ci Sokan. Perubahan penggunaan lahan menjadi permukiman meningkat sebesar 3,19% pada periode 1990-2000 dan 0,70% pada periode 2000-2010. Perubahan penggunaan lahan menjadi permukiman terutama berasal dari sawah, kebun campuran dan tegalan. Penambahan lahan permukiman dominan terjadi di sepanjang jalan yang melewati Kecamatan Cianjur, Cilaku, dan Karang tengah.

Penggunaan lahan yang cenderung mengalami peningkatan pada dua periode waktu tersebut adalah hutan, kebun campuran, dan perkebunan, masing-masing sebesar 2,12%, 3,11%, 0,48% pada periode tahun 1990-2000, dan 0,92%, 0,92%, 0,58% pada periode tahu 2000-2010. Pengurangan luas areal hutan terutama beralihfungsi menjadi kebun campuran dan tegalan.

Penggunaan lahan yang mengalami peningkatan pada periode 1990-2000 dan pengurangan pada periode 2000-2010 adalah sawah, masing-masing sebesar 3,19% dan -0,70%. Penambahan lahan sawah pada periode 1990-2000 banyak yang berasal dari hasil alihfungsi lahan kebun campuran, sedangkan pengurangan lahan sawah pada periode 2000-2010 karena berubah menjadi lahan permukiman. Berdasarkan analisis perubahan penggunaan lahan selama periode tahun 1990-2000 dan 2000-2010 bahwa perubahan penggunaan lahan di DA Ci Sokan berkisar 20-25%. Nilai perubahan penggunaan lahan tersebut merupakan angka yang cukup tinggi.

Faktor yang Mempengaruhi Perubahan Pertanian Lahan Kering

Analisis hubungan perubahan penggunaan lahan terhadap karakeristik lahan bertujuan mengetahui pengaruh tiap karakteristik lahan terhadap perubahan penggunaan lahan. Perubahan penggunaan lahan pada periode waktu 1990-2000 dan 2000-2010 relatf sama yaitu <25%, oleh karena itu periode waktu yang digunakan untuk membahas faktor-faktor yang berpengaruh terhadap perubahan penggunaan lahan adalah periode 1990-2010. Pada penelitian ini analisis yang dilakukan hanya pada perubahan pertanian lahan kering yaitu perubahan penggunaan lahan menjadi tegalan.

Analisis faktor yang mempengaruhi perubahan pertanian lahan kering dilakukan dengan analisis NNA dengan variabel tidak bebas adalah perubahan penggunaan lahan ke arah tegalan dan variabel bebas adalah kemiringan lereng, jenis tanah, ketinggian, curah hujan, jarak dari jalan, jarak dari sungai, jarak dari permukiman dan kepadatan penduduk. Setiap driving faktor akan mempunyai pengaruh yang berbeda pada setiap jenis perubahan penggunaan lahan, maka dilakukan pembobotan dengan iterasi (pengulangan) untuk menghitung kekuatan dari masing-masig driving faktor.

Hasil analisis menunjukan bahwa terdapat 6 (enam) penggunaan lahan yang berubah menjadi tegalan yaitu perubahan penggunaan lahan dari hutan, kebun campuran, perkebunan, sawah, tanah terbuka dan semak belukar. Selanjutnya keenam penggunaan lahan tersebut dikelompokan menjadi penggunaan lahan non tegalan untuk diketahui faktor yang memberikan peluang semakin besarnya perubahan ke arah tegalan. Hasil pembobotan menunjukan bahwa terdapat 4 faktor yang mendominasi perubahan penggunaan lahan non tegalan menjadi tegalan yaitu jarak dari permukiman, jarak dari jalan, ketinggian dan kemiringan lahan.

Faktor ketinggian berpengaruh terhadap semakin besarnya peluang perubahan penggunaan lahan menjadi tegalan. Secara spasial sebagian besar perubahan ke arah tegalan berada pada lahan-lahan yang memiliki ketinggian >700 m. Lahan-lahan yang berada dibawah ketinggian <700 m umumnya telah digunakan sebagai lahan sawah. Dengan kondisi ini para petani akan memilih lahan hutan di perbukitan yang berada pada elevasi yang tinggi untuk dijadikan tegalan.

Faktor jarak yang mempengaruhi peluang perubahan penggunaan lahan menjadi tegalan adalah jarak dari jalan dan jarak dari permukiman. Secara spasial perubahan dari non tegalan menjadi tegalan didominasi pada kisaran jarak >500-1000m jauh dari jalan dan jarak 1000-2000 m dari permukiman penduduk. Lahan-lahan yang dekat dengan jalan atau permukiman telah terlebih dahulu berubah menjadi persawahan dan didukung dengan karakteristik fisik lahan yang sesuai untuk persawahan serta aksesibilitasnya yang baik. Lahan yang berada jauh dengan jalan atau permukiman selain aksesibilitasnya yang kurang baik, pada umumnya berada pada lahan dengan karakteristik fisik lahan yang kurang mendukung untuk lahan persawahan, sehingga sangat besar peluangnya untuk berubah menjadi tegalan.

Faktor kemiringan lahan yang memiliki peluang besar dalam perubahan penggunaan lahan menjadi tegalan adalah lahan-lahan yang memiliki kemiringan lahan mulai dari landai sampai dengan bebukit. Fenomena ini mengilustrasikan bahwa perubahan dari non tegalan menjadi tegalan diawali dari lahan-lahan yang berada pada lereng yang landai kemudian berangsur ke daerah yang memiliki kemiringan sampai dengan berbukit. Lereng yang memiliki kriteria curam peluang terjadinya perubahan menjadi tegalan sangatlah kecil.

Hasil analisis faktor penyebab perubahan pertanian lahan kering di DA Ci Sokan sesuai dengan penelitian yang dilakukan oleh Affifudin (2012) tentang Pemodelan Spasial Perubahan Penggunaan Lahan Kawasan Gerbangkertosusilo. Salah satu hasil analisisnya menyebutkan bahwa perubahan kearah pertanian lahan kering dipengaruhi oleh ketinggian dan lereng.

Proyeksi Penggunaan Lahan 2015

Peluang perubahan penggunaan lahan pada periode waktu 2000-2010 berkisar antara 0,0002-0,3798. Peluang perubahan terkecil terjadi pada perubahan hutan menjadi tanah terbuka dan perubahan terbesar terjadi pada perubahan dari tanah terbuka menjadi kebun campuran. Proyeksi penggunaan lahan kedepan menggunakan ketiga model menghasilkan proyeksi penggunaan lahan pada tahun 2015. P enggunaan lahan dari masing-masing model memiliki luas yang berbeda. Hal ini dikarenakan matrik peluang penggunaan masing masing model memiliki nilai yang berbeda. Trend perubahan penggunaan lahan dari tahun 2010 ke proyeksi penggunaan tahun 2015 umumnya masing-masing model memberikan peningkatan pada beberapa penggunaan lahan seperti sawah, permukiman, perkebunan, semak belukar, dan tegalan. Situ/danau/telaga cenderung tidak berubah, hal ini disebabkan peluang danau /telaga dan tanah terbuka berubah menjadi penggunaan lahan lainnya sangat kecil.

Validasi Model

Diantara bentuk perubahan akibat krisis ekonomi adalah meningkatnya kecepatan kemiskinan, meningkatnya penganguran, melonjaknya angka inflasi, dan hilangya daya beli konsumer. Jamal (2000) menyebutkan bahwa krisis ekonomi berakibat tingginya angka pengangguran yang menyebabkan menurunnya pendapatan masyarakat. Sejak awal krisis para ahli dan pembuat kebijakan menganjurkan untuk memberikan perhatian khusus di bidang pertanian sebagai upaya untuk mencari jalan keluar dari krisis. Pertanian banyak menyerap tenaga kerja dan sangat penting dalam mengatasi pengangguran. Kepercayaan yang diberikan pada sektor pertanian secara umum telah terbukti. Dari awal mula krisis sampai kuartal ketiga tahun 1998, secara nasional sektor pertanian menunjukan pertumbuhan 0-1% melebihi sektor-sektor lainnya. Selain itu, dari tahun 1997 sampai 1998, sumbangan pertanian terhadap total jumlah tenaga kerja meningkat dari 40,7% menjadi 45,0% (Sunderlin et al, 2000).

Sunderlin et al (2000) menyebutkan bahwa selama masa krisis petani cenderung bereaksi terhadap harga komoditi pertanian yang lebih tinggi dengan jalan memperluas lahan garapannya atau dengan cara meningkatkan intensitas produksinya melalui pengelolaan yang lebih baik. Krisis ekonomi berdampak nyata terhadap kehidupan petani, pengaruhnya dapat dilihat pada masa bera (lahan kosong yang tidak ditanami) dan praktek pembukaan lahan hutan yang dikonversi menjadi pertanian. Krisis ekonomi Indonesia terhadap petani kecil dan tutupan hutan alam menunjukan bahwa sebanyak 68% dari total responden telah membuka lahan baru untuk pertanian yaitu berupa perladangan berpindah dan pertanian menetap. Hal ini serupa dengan kondisi yang terjadi dai DA Ci Sokan. Pada periode 1990-2000 di DA Cisokan pembukaan lahan hutan yang dikonversi menjadi tegalan sebesar 1.873 ha atau 1,60% dari luas DA. Pembukaan lahan hutan menjadi tegalan pada periode 1990-2000 lebih besar dua kali lipat dibandingkan dengan periode 2000-2010 yang hanya sebesar 739 ha atau 0,63% dari luas DA.

Proyeksi Pertanian Lahan Kering 2030

Terdapat empat jenis penggunaan lahan mengalami penurunan luas tahun 2030 yaitu hutan, kebun campuran, perkebunan dan tanah. Hutan dan kebun campuran mengalami penurunan yang cukup signifikan yaitu sebesar 7,7 % dan 9,3%. Menurunnya luas hutan perlu mendapatkan perhatian dikarenakan dengan semakin kecilnya luasan hutan di DA Ci Sokan maka potensi gangguan hidrologis baik di DA tersebut maupun kawasan di bawahnya semakin besar. Berkurangnya luas hutan dapat mengakibatkan ganguan keseimbangan tata air seperti banjir, erosi, dan sedimen.

Penggunaan lahan yang diprediksi meningkat luasannya pada tahun 2030 adalah permukiman, sawah, semak belukar, tanah terbuka dan tegalan. Sawah dan permukiman meningkat sebesar 3,0 % dan 6,5 %. Pertanian lahan kering berupa tegalan pada tahun 2030 diprediksi meningkat sebesar 2.316 ha atau 16,5% dari tahun 2015.

Prediksi Erosi yang Terjadi di DA Ci Sokan

Prediksi erosi pada penelitian ini berasumsi bahwa nilai erosivitas hujan tidak mengalami perubahan. Namun apabila melihat trend perubahan iklim yang terjadi, nilai erosivitas sangat dimungkinkan memiliki nilai yang lebih tinggi dengan perhitungan sebelumnya sehingga nilai erosi akan semakin tinggi. Perubahan iklim akan berdampak pada pergeseran musim yakni semakin panjangnya musim kemarau dan semakin singkatnya musim hujan namun dengan curah hujan yang lebih besar (Rusbiantoro, 2008). Intensitas curah hujan yang tinggi akan berdampak pada besarnya potensi erosi yang terjadi. Arsyad (2010) menyatakan bahwa terdapat korelasi yang erat antara intensitas curah hujan maksimum selama 30 menit (EI30) dengan besarnya erosi.

Pengaruh Perubahan Pertanian Lahan Kering terhadap Erosi

Perubahan lahan hutan, kebun campuran, perkebunan, sawah dan semak belukar yang beralihfungsi menjadi tegalan cenderung meningkatkan erosi, sedangkan untuk tanah tebuka yang beralihfungsi menjadi tegalan cenderung akan menurunkan erosi. Peningkatan erosi terbesar jika lahan hutan berubah menjadi tegalan. Lahan hutan di lokasi penelitian yang berubah menjadi tegalan meningkatkan erosi rata-rata sebesar 634,04 ton/ha/thn. Berdasarkan Undang-Undang No.42 tahun 1992 yang menyebutkan bahwa pada lahan dengan kelerengan di atas 40% harus diperuntukan vegetatif tetap, sedangkan kenyataan di lapangan pada kelerengan lebih dari 40% (sangat curam) masih ditanami palawija dan sayuran. Budidaya sayuran di lokasi penelitian dilakukan secara intensif, ditandai dengan keberadaan pertanaman sayuran yang senantiasa ditanam sepanjang tahun, karena ditunjang oleh curah hujan yang cukup dengan penyebaran merata.

Umumnya pertaninan lahan kering di DA Ci Sokan ditanami oleh tanaman palawija dan hortikultura semusim seperti tanaman kentang, bawang daun, wortel, kubis, dan petsai/sawi. Jenis tanaman yang diusahakan oleh petani memang memberikan hasil produksi yang sesuai dengan harapan dan menjadi andalan pendapatan untuk para petani pertanian lahan kering. Dalam budidaya palawija dan sayuran, petani umumnya tidak menerapkan teknik konservasi tanah yang baik untuk mengendalikan erosi, padahal lahan sayuran terletak pada topografi dengan bentuk wilayah bergelombang, berbukit sampai bergunung, sehingga tanah akan sangat mudah tererosi.

Pengelolaan lahan pada pertanian lahan kering di lokasi penelitian umumnya sederhana dan bersifat tradisional. Dalam budidaya sayuran, baik yang dilakukan di dataran rendah maupun dataran tinggi, petani melaksanakan usaha taninya dalam bedengan atau guludan. Pada lahan kering berlereng di dataran tinggi, bedengan atau guludan umumnya dibuat tidak mengikuti kaidah-kaidah konservasi tanah yang baik dan benar. Bedengan atau guludan dibuat memanjang searah lereng sehingga tanah di dalam bedengan atau guludan tersebut mengalami erosi pada saat hujan, dan terjadi peningkatan jumlah aliran permukaan, yang pada akhirnya akan meningkatkan debit sungai dengan kandungan lumpur yang tinggi. Kondisi seperti ini akan mempercepat hilangnya lapisan lapisan atas yang subur, dan pada akhirnya terjadi kerusakan tanah akibat lahannya digunakan untuk budidaya sayuran secara terus menerus.

Penerapan teknik konservasi sangat berperan dalam mencegah terjadinya degradasi lahan. Petani sebagian besar menyatakan belum memahami faktor utama penyebab kerusakan lahan dan banyak dari petani yang tidak melakukan tindakan konservasi dalam berusahatani. Hanya beberapa petani saja yang melakukan pencegahan kerusakan lahan dengan melakukan tindakan konservasi melalui pemeliharaan teras dengan pemakaian mulsa, guludan memotong lereng, dll. Keterbatasan petani dalam upaya pelestarian sumberdaya lahan menurut mereka karena kurang modal dan pengetahuan serta pemahaman tentang erosi, disamping akibat yang ditimbulkannya. Kondisi inilah yang menyebabkan penurunan produktivitas sumberdaya lahan. Hal ini sesuai dengan Erfandi et al., (2002) yang menyatakan bahwa menurunnya produktivitas sayuran di dataran tinggi adalah akibat para petani tidak menerapkan teknik konservasi tanah dalam usaha taninya, sehingga tanah yang hilang dari lahan budidaya cukup besar.

Dari hasil proyeksi penggunaan lahan dan analisis erosi sampai dengan tahun 2030, perubahan penggunaan lahan DA Ci Sokan cukup menghawatirkan terutama perubahannya menjadi pertanian lahan kering seperti tegalan yang cenderung meningkatkan laju erosi. Selain mengurangi produktivitas lahan besarnya erosi saat ini atau pada tahun 2030 dapat semakin memperburuk fungsi hidrologis DAS tersebut. Sedimen yang berada di Waduk Cirata dikhawatirkan semakin banyak dan mempersingkat umur guna waduk tersebut. Hal ini sangatlah merugikan dikarenakan fungsi dari Waduk Cirata sangatlah vital seperti pembangkit listrik tenaga air, perikanan, produksi, dll.

Kesimpulan

Selama kurun waktu tahun 1990-2010 telah terjadi perubahan pertanian lahan kering secara signifikan. Secara spasial perkembangan lahan tegalan terjadi pada daerah yang memiliki ketinggian antara 700-1000 mdpl dan kelas lereng agak curam (15-25%) dan curam (25-40%).

Model spasial perubahan pertanian lahan kering dengan menggunakan Model II (2000-2010) memberikan tingkat kesesuaian yang tinggi dibanding dengan model lainnya, yaitu dengan nilai Kappa sebesar 0,8719. Pertanian lahan kering DA Ci Sokan pada tahun 2030 diprediksi meningkat sebesar 16,5% dari tahun 2015 dimana secara spasial menunjukan perkembangan yang sama dengan periode sebelumnya.

Luas lahan yang tererosi pada setiap kelas erosi tahun 1990-2030 diprediksi terus meningkat untuk kelas erosi sedang sampai dengan sangat berat. Perubahan luasan tingkat bahaya erosi terjadi seiring dengan perubahan penggunaan lahan menjadi tegalan. Berkembangnya luas tegalan diduga akan memicu tingginya muatan sedimen DA Ci Sokan, yang selanjutnya diendapkan di Waduk Cirata.

Analisis Pencemaran Udara di Leeds Selama Puncak Arus Lalu Lintas

An Analysis of Air Pollution in Leeds during Peak Traffic Times

Nama	: Frans Janporta Sitepu
NIP	: 198410062009121002
Instansi	: BPN
Tahun Intake	: 2015
Tingkat Beasiswa	: Master Overseas
Program Studi	: Geographic Information Science (MSc)
Negara Studi	: Britania Raya
Universitas	: Birkbeck University of London

ABSTRAK

Kontaminasi udara adalah masalah khas di sebagian besar wilayah perkotaan di bumi. Masalah ini terutama terjadi karena pembuangan toksin udara dari sistem pembakaran bahan bakar fosil; dan terutama lalu lintas dan emisi kendaraan bermotor, menyebabkan polusi udara. Polusi udara dapat ditandai dengan diperkenalkannya partikel biologis atau partikel molekuler lainnya, atau pengenalan bahan berbahaya lainnya ke atmosfer Bumi.
Studi saat ini menguraikan penyelidikan terhadap tingkat bahan partikulat yang berkontribusi terhadap polusi udara yang terjadi pada saat lalu lintas puncak di Kota Leeds, Inggris. Dengan demikian, penelitian ini akan membangun penelitian yang ada untuk mengembangkan dasar teori yang kuat untuk membangun interpretasi yang berarti terhadap data yang dikumpulkan. Komponen penelitian untuk penelitian ini akan beroperasi dalam dualitas, menggabungkan elemen penelitian sekunder dengan identifikasi dan pengumpulan data primer, dalam bentuk penebangan sensorik jarak jauh terhadap kondisi udara di dalam dan sekitar Leeds. Itu benar seperti yang diharapkan bahwa daerah sekitar lokasi kemacetan lalu lintas lebih dipengaruhi oleh emisi kendaraan karena kedekatannya dengan sumber daripada yang lebih jauh. Studi tersebut menemukan bahwa sumber arus keluar terbesar cenderung ke arah transportasi jalan diikuti dengan penggunaan pelarut.

ABSTRACT

Air contamination is a typical issue in most urban regions on earth. The issue takes place primarily because of the discharges of air toxins from fossil fuel burning systems; and particularly traffic and vehicular emissions, causing air pollution. Air pollution can be characterized by the introduction of biological or other molecular particulate, or the introduction of other harmful materials to the atmosphere of the Earth.

The current study outlines an investigation into the levels of particulate matter contributing to air pollution that occurs during peak traffic times within the City of Leeds, United Kingdom. Accordingly, the study will build upon extant research in order to develop a sound basis of theory upon which to construct a meaningful interpretation of the gathered data. The research component to this study will operate in a duality, combining a secondary research element with the identification and gathering of primary data, in the form of remote sensory logging of air conditions in and around Leeds. It was right as expected that areas surrounding traffic congestion locations are more greatly affected by vehicular emissions due to their proximity to the source rather than those farther away. The study found that the biggest single outflow source is inclined towards that of being street transport followed by usage of solvents.

Background

Air contamination is a typical issue in most urban regions on the planet. The issue takes place primarily because of the discharges of air toxins from fossil fuel burning systems; and particularly traffic and vehicular emissions (Lee, Mukhopadhyay, Rushworth & Sahu, 2016). Among the numerous air contaminations, a great deal of attention has been paid to the nature of VOCs (Volatile Organic Compounds) and their position as the most prominent gatherings of air toxins. This is on account of their state as not just antecedents for the development of photochemical oxidants be that as it may, a few structures, similar to butadiene, benzene and formaldehyde, are likewise known not to be cancer-causing agents (Mearns, 2009).

It is commonly understood that VOCs respond with NO, to shape photochemical oxidants within the sight of daylight, prompting mid-year exhaust cloud scenes in urban ranges with high populace. VOCs emerge from utilization of fossil fills in both stationary and versatile sources furthermore from utilization of solvents for modern and residential purposes (Coulson, 2016). Likewise with other air toxins, street transport is one of the biggest patrons to VOC emanations. Street transport contributed over 80% of the anthropogenic VOC emanations in the UK in 2015 (Longhurst, 2016).

The photochemical responses which occur in sunlight of natural mixes within contact of nitrogen oxides produce lifted convergences of ozone which emanate and develop over the majority of the nations of Europe (Lomas, Schmitt, Jones, McGeorge, Bates, Holland & Weatherly, 2016). These lifted ozone fixations may surpass the globally acknowledged air quality models which have been established in order to ensure human wellbeing is maintained (Lee, Mukhopadhyay, Rushworth & Sahu, 2016). As a consequence to damaging reports, asserted activity has been taken inside the United Nations Economic Commission for Europe and its traditional position on long-range transportation and according limitation of air contamination (Ambarwati, Verhaeghe, van Arem & Pel, 2016). Recognition has also been made in the form of control pertaining to the discharges of unpredictable natural mixes such as VOCs and nitrogen oxides (NOx) within changes to the European Commission and its Clean Air for Europe program (Malkin, Heard, Hood, Stocker, Carruthers, MacKenzie & Laufs, 2016).

A critical thought in photochemical ozone development is that each VOC compound, in addition to the possibilities of the inclusion of many hundreds more, shows an alternate reactivity or penchant for ozone arrangement (Dollard et al., 2007). This affinity shifts on account of their diverse and inborn substance conduct (Carter & Atkinson, 1989). Each VOC outflow source discharges a distinctive blend of VOCs and subsequently each, essentially, makes an alternate commitment to photochemical ozone development (Fathallah, Lecuire, Rondeau & Le Calvé, 2016). It is vital that the arrangement activities embraced to control the emanations of the VOCs across cities in Europe, handle those sources that contribute most to photochemical ozone arrangement

(Bristow, 2016). Reactivity can be measured in a few routes (Malkin, Heard et al., 2016). However, here we take the idea to allude to the measure of ozone shaped amid a given time period, taking after the emanation of a given mass of a natural compound or source emanation. On account of concerns surrounding ozone arrangement may be exceptionally nonlinear, consideration is coordinated to some quantify of incremental reactivity and not to some outright measure of ozone development (Schmitt, 2016).

The current study is based upon a central motivation to ascertain the extent to which pollution levels due to airborne particulate matter generated from vehicular emissions affect immediate and surrounding areas. The key objectives for the study can be summarized in the following statements:

- To establish to what extent vehicular emission levels differ in Leeds according to the 20 year testing range (from 1993 to 2013).
- To establish to what extent vehicular emission levels differ in Leeds according to time of day.
- To establish to what extent vehicular emission levels differ in Leeds dependent on traffic concentrations.

These points will be established throughout the development of the study and will be based upon the scrutiny of extant literature in conjunction with remote sensory information. Accordingly, the null hypothesis is as follows:

- Surrounding areas of traffic congestion zones will not demonstrate any observable difference to those in areas that are not coterminous to such zones.

The research component to this study will operate in a duality, combining a secondary research element with the identification and gathering of primary data, in the form of remote sensory logging of air conditions in and around Leeds. The remote sensor information will be gathered from timely and current sources gathered from the literature review; and as such, will be delineated throughout the course of the analysis and the discussion. A definite and detailed delineation of the systems employed by the selected studies is beyond the scope of the current methodology but can be explained in greater detail within the referenced materials upon which the current methods are based. Where appropriate, these systems will be explained within the current research. The accompanying is accordingly a synopsis of the methodology which has been utilised in the current approach. The VOC source classes employed within the current methodology are those which have been utilised within the UK national emission statistics (see Schmitt, 2016).

Overview

It was expected that areas surrounding traffic congestion locations will be more greatly affected by vehicular emissions due to their proximity to the source rather than those farther away. Outflows of VOCs in Leeds are evaluated to be 50 kt (kilotons) in 1993 (Clarke & Ko, 1996). By a wide margin the biggest single outflow source is inclined towards that of being street transport. The street transport contributes 96.4% of the aggregate VOC outflows inside the study zone. Usage of solvents is the second largest responsible contributor for 26.4% of the aggregate emission totals employed. Commitments of other sources are comparatively low, contributing 14.2% overall.

Discharges from biogenic sources were generally low, representing just 3.4% of the total emissions data. This is on the grounds that the area of study is a profoundly urbanized city and in this way has just a little forest region within its boundaries. As can be found in the data, the commitments of street transport to aggregate discharges vary from one city or nation to another. The commitment of street transport in the study region is higher than the UK's national normal range and is similar with other nations (Risom, Møller & Loft, 2005). The higher commitment of street transport contrasted with the national figure is expected to the non- attendance of oil refineries and minor commitments of some potential sources; for example, the iron and steel industry, horticulture and regular sources.

In connection to commitments by various vehicle classifications to aggregate street vehicular emanations, the data shows that the biggest patron is petrol powered automobiles, contributing around 78% of the vehicular outflows in the study territory. Petrol light duty vehicles (LDVs) and diesel fuelled heavy goods vehicles (HGVs) are contributory to around 2.2%, individually. The remaining contributions are produced by other vehicles.

VOC Emissions

During the time spent photochemical oxidation, individual VOC species impact the creation of oxidants, for example, ozone, in an unexpected way. The relative emanation quality of individual species is subsequently essential for the evaluation of VOC outflows. In the current dataset, around 91% of the aggregate discharges have been speciated into VOC classifications of a general form, utilizing fingerprints for discharge sources. The inability to speciate the remaining discharges took place as a consequence to the absence of fingerprints or lacking information of species discharged from a few sources. The data indicates relative discharge qualities of sorted VOC species as compelling. Street transport is a prevailing emanation origin of alkenes, alkynes, aromatics and aldehydes, representing 96% of alkynes, 81% of alkenes, 63% of aromatics, and 94% of aldehydes. For different species use of solvents is an overwhelming source, in charge of 91% of ketone outflows, 93% of alcohols and 98% of acetic acid derivations and compounds that are chlorinated.

Presentation of the idea of POCP in outflow lessening arranging will be valuable to moving forward in modern surroundings in a financially savvy way. Thus VOC outflows are regularly weighted with the POCP esteem for every species to discover commitment of individual mixes. Every one of the outflows could not be POCP-weighted because of lacking data. In the current investigation, approximately 74% of the aggregate outflows have been POCP-weighted and the outcomes show how relative source commitments contrast either side of POCP-weighting timescales. The relative commitment of street transport has been expanded from 57 to 66% because of the high extent of aldehydes in conjunction with compounds which are aromatic; for example, benzene, toluene and xylenes with moderately high POCP values in petrol emissions while the commitment of solvent use has been diminished from 31 to 28% due to the usage of solvents for the purposes of painting, printing, surface cleaning, and other uses as largely responsible for alcohols, ketones and compounds that are chlorinated; all of which having generally low POCP values.

Spatial Disaggregation

Through spatial disaggregation, commitments by source classification have been dissected for the inward territory, (downtown area – see Appendix) and the external range (Ambarwati, Verhaeghe, van Arem & Pel, 2016). Around 94% of the aggregate outflows have been disaggregated into squares forming a grid due to the limitation of the depiction with regards to presentation of chemical matter. The lack in spatial disaggregation is because of absence of data on the areas of some outflow sources, such as horticultural farm activity, smaller businesses and similar activities. The outcomes are highlighted in the data. Commitments of street transport in the internal territory (41% of the total emissions) are essentially lower than in the external range (62%). The completely disaggregated data is delineated in the data. Actually, commitments of dissolvable use in the inward region are higher than in the external range (31%). This is on the grounds that there are numerous point sources utilizing natural solvents and delivering a lot of VOCs in the internal range.

The best diminishments over the period, in overall terms, have been from a variety of factors; including the combustion of rural waste (28 tons); aluminum generation (25 tons); street vehicles (5 tons); and private discharges (3 tons). UK information (see Bristow, 2016) demonstrates that PAH focuses have diminished prior to 1990 and this has been indicated by the decline in Bap fixations which additionally demonstrates the outflows change. It is hard to create an agent normal UK esteem for PAH fixations in light of the adjustments in observing site area and number that have happened in the PAH checking system in the course of the most recent 20 years. Be that as it may, as indicated by Butterfield and Brown (2012), a sensible representation of a normal UK PAH fixation can be given by the middle yearly esteem over all destinations on the PAH Network.

It has been maintained in the literature (Ehsani, Gao & Emadi, 2009) that both outflows and measured groupings of BaP discharges have diminished drastically in the course of the most recent 20 years. It is additionally clear that these abatements are very associated. For a long stretch, for example, 20 years, the impact of inter-annual varieties in meteorology will be small, however will represent a portion of the variety appeared for BaP focuses in the data. The high level of relationship amongst outflows and focuses is to some degree amazing given the progressions to the PAH checking system over this period and the huge abatements in emanations from farming field burning and the generation of aluminum, which may be relied upon to have altogether different effects on surrounding fixations at various areas (Li, Andrews, Savvidis, Daham, Ropkins, Bell & Tate, 2008). The diminishments in emanations from aluminum generation have been commonly relied upon in such studies to have an effect at checking destinations near particular plants; for example, the decay of the yearly mean BaP fixation at Kinlochleven from 6.8 ng m-3 in 1999 to 0.34 ng m-3 in 2001 connected with the conclusion of the plant (ibid.). Decreases in emanations from street movement and private outflows would be required to have a more broad effect at observing stations over the UK. Along these lines, while plainly emanations and focuses have diminished after some time, the purposes behind the lessening cannot be related with certainty unless more consideration is given to how singular locales are influenced by particular outflow sources.

Conclusion

Firstly, with regards to VOC outflows street transport was the biggest benefactor, capable of the production of 52% of the aggregate anthropogenic discharges inside the city of Leeds in 1993, contrasted with 34% for the UK all in all. The second biggest benefactor was found to be the use of solvents which contributed 41%. Additional sources were just minor benefactors. Forms of street transport included affecters such as the petrol-fuelled auto as the biggest patron, adding up to 71% of the aggregate vehicular emanations. Among others, petrol fuelled LDVs and HGVs running on diesel contributed 12 and 8%, separately. For that part of the aggregate stock with which speciation could be achieved, the impact of POCP weighting was to build the commitment of street transport from 64% of the aggregate emanations to 68%; while the proportion contributed by the use of solvents was diminished from 35 to 27%.

This is because of substantial emanations of VOC species with high POCP values from street vehicles. The consequences of speciation demonstrate that street transport is liable for 81% of alkene emanations, 61% of aromatic emissions and 97% of alkynes. In addition, 94% of aldehydes were associated while solvent use has been found to be responsible for 96% of ketone emanations, 92% of alcohols, and 100% of compounds associated with chlorine and acetic acid derivations. Contributions of street transport in the inward range (41%) are fundamentally lower than those in the external region (62%). Alternatively, the commitments associated with the usage of solvents in the internal zone (51%) are higher than in the external region (31%) due to the discharges from point sources in the inward region.

The examination of outflow and encompassing focus patterns ought to be completed with greater frequency given that it can give the main signs of irregularities between the two, which can be caught up with more fundamental work. This is an extremely valuable strategy that can ready inventories to wrong patterns in discharges from a particular source or gathering of sources (for example, street transport) and direct stock gatherings to maybe where these ought to be reassessed. The most applicable linkage with emanation inventories is the examination with long haul patterns for particular source divisions. Contingent upon how the surrounding information have been handled these source segments may incorporate, for instance, urban street transport outflows. However, the method may not pinpoint the definite source which is under suspicion of erroneousness, such as which particular vehicle sort, and whether it is an issue with emanation components or treatment of exercises, or in the stock estimation technique. In many cases, the procedure is helpful for illuminating issues with neighbourhood inventories created from nearby information, such as the development of the vehicle armada and activity streams. Notwithstanding, given the chance that this data is known precisely, it could pinpoint issues with emanation components important to national inventories.

Fixation proportions are additionally valuable for cautioning inventories to clashes, yet less helpful for indicating what component of the stock ought to be altered; for example, which contamination, outflow component or movement information. It is possibly helpful for distinguishing mistakes in inventories in regards to the blend inside gatherings of comparable poisons. For instance, it can advise the stock straightforwardly on whether the VOC speciation for a particular source, for example, street transport is right if the estimations are made at the roadside.

Sensitivitas dan Kapasitas Adaptif Permukiman Kumuh terhadap Bencana Banjir dan Kebakaran di Kota Bekasi

Slum's Sensitivity and Adaptive Capacity Against Floods and Fires in Bekasi City

Nama	: Lia Fitriasari Rahayu
NIP	: 198307262009032003
Instansi	: BPN
Tahun Intake	: 2013
Tingkat Beasiswa	: Master Local
Program Studi	: Magister Ilmu Geografi
Negara Studi	: Indonesia
Universitas	: Universitas Indonesia

ABSTRAK

Selama ini penataan perkotaan kurang memperhatikan kondisi internal dan aspek penyesuaian diri terhadap bencana yang sering melanda permukiman kumuh. Penelitian ini bertujuan mengungkapkan sebaran permukiman kumuh dan menganalisis tingkat sensitivitas dan kapasitas adaptif permukiman kumuh terhadap bencana banjir dan kebakaran secara spasial. Sebaran permukiman kumuh diperoleh melalui metode interpretasi foto udara dan metode *Spatial Multi Criteria Evaluation* (SMCE) digunakan untuk menganalisis tingkat sensitivitas dan kapasitas adaptif. Hasil analisa menunjukkan permukiman kumuh tersebar pada sempadan sungai, sempadan rel kereta, sekitar daerah pertanian/RTH, sekitar kompleks perumahan, sekitar daerah komersil dan sekitar TPA. Permukiman kumuh dengan tingkat sensitivitas tinggi dan kapasitas adaptif rendah terhadap banjir terkonsentrasi di sempadan sungai. Tingkat sensitivitas tinggi dan kapasitas adaptif rendah terhadap kebakaran terpusat pada permukiman kumuh di sekitar TPA.

Kata kunci : permukiman kumuh, sensitivitas, kapasitas adaptif, banjir, kebakaran.

ABSTRACT

All this time the arrangement of the urban is lack of attention to internal conditions and aspects of adapt to the disasters that often plagued slums. This study aims to reveal the spread of slums and inform the level of sensitivity and adaptive capacity of slum against floods and fires spatially. The distribution of slums obtained through aerial photos interpretation method and Multi Criteria Evaluation method (SMCE) method used to analyze the level of sensitivity and adaptive capacity. The result shows slums spread across the border river, the border railway, near a commercial area, near the landfill, in an agricultural area/green space and around the housing complex. Slums with high sensitivity and low adaptive capacity against floods is concentrated in the border river. Slums with high sensitivity and low adaptive capacity to fires concentrated near landfill.

Keywords: Slums, sensitivity, adaptive capacity, floods, fires.

Latar Belakang

Daerah kumuh mempunyai permasalahan terhadap kondisi sosial ekonomi yang rendah dan degradasi lingkungan. Keadaan lingkungan yang buruk mengakibatkan suatu kawasan rawan akan bahaya dan bencana, yaitu bencana banjir, resiko kebakaran dan penyakit endemik. Sebagai permasalahan yang identik dengan eksistensi permukiman kumuh, bencana banjir merupakan bencana yang paling sering terjadi secara merata di Indonesia yakni berada pada urutan tertinggi dari seluruh jenis bencana yang terdapat di Indonesia. Selain banjir, bencana kebakaran sebagai permasalahan yang umum terjadi di permukiman kumuh, berasal dari faktor kesalahan manusia *(human error)* yang beraktivitas di dalamnya. Sehingga terbentuklah hipotesis awal bahwa lingkungan permukiman kumuh merepresentasikan keadaan perekonomian menengah ke bawah yang berimplilkasi pada rendahnya tingkat pendidikan sehingga menyebabkan rendahnya tingkat kepedulian akan keselamatan dalam bermukim. Demikian pula Oktaviansyah (2012) juga memaparkan bahwa kebakaran umumnya terjadi karena adanya sejumlah pemicu yang dapat disebabkan oleh berbagai faktor antara lain pembakaran sampah, puntung rokok, hubungan pendek arus listrik, maupun kondisi lingkungan permukiman yang buruk yang dapat ditemui pada permukiman kumuh.

Menurut UNDP (2013), hasil studi menunjukkan bahwa keterpaparan terhadap perubahan yang menyebabkan terjadinya bencana merupakan sebuah kenyataan yang dialami di banyak kota di Indonesia. Kota-kota itu dapat mengurangi kerentanan manusia terhadap bencana dengan memberikan pengaruh terhadap sensitivitas dan kapasitas beradaptasi penduduknya, dengan beragam tindakan baik secara fisik maupun non fisik. Masyarakat miskin yang tinggal dan bekerja di wilayah-wilayah yang rawan, sangat sensitif terhadap bencana karena mereka tidak banyak memiliki kemampuan untuk merespons atau menghindar. UNDP (2013) juga menyatakan bahwa permasalahan permukiman informal tidak selalu harus dihubungkan dengan kerentanan, mereka dapat saja merupakan masyarakat yang memiliki dukungan sosial dan berkembang secara ekonomi, namun mereka seringkali tidak banyak mendapat pelayanan sosial, infrastruktur air bersih dan sanitasi, serta umumnya pemukiman ini terletak di wilayah-wilayah yang mudah terpapar oleh banjir. Melalui sensitivitas dan kapasitas adaptif, akan dihasilkan kajian yang lebih spesifik yang berbasis kondisi lingkungan setempat karena sensitivitas mampu mengaitkan antara ancaman bencana dengan konteks sosial ekonomi dari permukiman kumuh yang terkena dampak dan kapasitas adaptif sebagai kemampuan sistem dalam hal ini permukiman kumuh untuk menyesuaikan terhadap bencana dengan tujuan mengurangi potensi kerusakan dan memanfaatkan peluang yang dimiliki dalam menghadapi bahaya.

Kota Bekasi sebagai bagian dari metropolitan Jakarta, pemanfaatan wilayahnya menurut RUTRK Jabodetabekjur-Punjur (2006) diarahkan terutama untuk perumahan hunian dengan kepadatan tinggi, perdagangan dan jasa skala nasional serta industri ringan. Jadi tidaklah mengherankan bila sekitar 71,6% luas Kota Bekasi merupakan wilayah permukiman (RTRW Kota Bekasi Tahun 2012). Kota Bekasi memiliki kemudahan dan kelengkapan sarana dan prasarana transportasi ke kawasan metropolitan Jabodetabek sehingga jumlah pekerja di Jabodetabek yang bermukim di Kota Bekasi terus meningkat. Laju pertumbuhan penduduk Kota Bekasi dari tahun 2000 hingga tahun 2009 sebesar 3,21%. Laju pertumbuhan penduduk ini terus meningkat dari tahun 2009 ke tahun 2013 sebesar 4,11%. Namun peningkatan jumlah penduduk di Kota Bekasi tidak sebanding dengan ketersediaan lahan untuk tempat tinggal, sehingga di beberapa tempat terjadi kondisi lingkungan tempat tinggal yang padat penduduk atau yang disebut dengan permukiman kumuh (Widartono dan Adeline, 2012). Bahkan berdasarkan observasi awal, permukiman kumuh yang ada di Kota Bekasi tersebar merata di seluruh bagian kota. Meratanya distribusi permukiman kumuh ini dikhawatirkan dapat meningkatkan perkembangan permukiman kumuh apabila tidak dilakukan penanganan secara tepat.

Berdasarkan indeks kerawanan bencana yang dibuat oleh BNPB (2011), Kota Bekasi memiliki tingkat kerawanan bencana tinggi, dimana bencana utama yang terjadi di Kota Bekasi adalah banjir. Berdasarkan RTRW Kota Bekasi Tahun 2013, terdapat 1.230 Ha dari 19.709 Ha luas Kota Bekasi yang termasuk ke dalam kawasan rawan banjir. Wilayah yang terdampak bencana banjir di Kota Bekasi sejak tahun 2009 terus mengalami peningkatan hingga saat ini. Tercatat terdapat 676,8 Ha area yang terendam banjir di 11 kecamatan dari 12 kecamatan yang ada di Kota Bekasi (Dinas Pekerjaan Umum Kota Bekasi, 2013) dengan luasan area terluas yang terendam banjir berada di Kecamatan Bekasi Timur. Selain banjir, Kota Bekasi juga rentan terhadap ancaman kebakaran. Kantor Pemadam Kebakaran Kota Bekasi (2014) menyatakan bahwa selama tahun 2014 telah terjadi 169 kejadian kebakaran dengan faktor penyebab kebakaran didominasi dari faktor konsleting listrik. Kebakaran yang paling banyak terjadi di rumah tinggal ini juga melanda permukiman kumuh di Kota Bekasi.

Salah satu metode peningkatan permukiman (kumuh) dalam konteks konsep penataan permukiman yang digagas oleh Departemen Pekerjaan Umum Direktorat Jenderal Cipta Karya (2010) didasarkan atas kebutuhan kondisi lingkungan dan kesiapan bencana sehingga pemenuhan hak dasar penghuni permukiman untuk hidup dengan layak dapat terpenuhi. Konsep penataan ini memerlukan pengkajian terhadap tingkat sensitivitas yang menunjukkan derajat kerawanan terhadap gangguan serta pengkajian terhadap kapasitas adaptif sebagai kemampuan penyesuaian diri, dalam hal ini terhadap bencana banjir dan kebakaran. Artinya metode penataan yang dipilih pemerintah mampu mengatasi ancaman dari kondisi lingkungan permukiman kumuh serta mampu meningkatkan kapasitas adaptif yang telah dimiliki.

Upaya pengambilan kebijakan dalam penataan permukiman oleh pemangku kepentingan terutama yang disebabkan oleh kejadian bencana banjir dan kebakaran sering mengedepankan pendekatan “akibat” yang mungkin tidak menyentuh bahkan tidak menyelesaikan permasalahan internal sesungguhnya yang terjadi. Melalui pendekatan berbasis “sebab” akan lebih tepat sasaran karena mempertimbangkan kondisi internal sistem tersebut menghadapi ancaman yang akan terjadi. Untuk itu dalam menyusun konsep penataan permukiman kumuh di Kota Bekasi, perlu dilakukan kajian sensitivitas dan kapasitas adaptif terhadap bencana banjir dan kebakaran terlebih dahulu.

Disamping itu, selama ini pemahaman dan informasi mengenai sensitivitas dan kapasitas adaptif dalam bencana banjir dan kebakaran masih sangat terbatas. Terutama pada permukiman kumuh di Kota Bekasi. Dengan kondisi Kota Bekasi yang sering mengalami bencana banjir dan kebakaran termasuk di permukiman kumuhnya, maka sensitivitas dan kapasitas adaptif yang mengangkat kondisi faktual sebuah lingkungan dalam menghadapi ancaman, sangat diperlukan dalam penanggulangan bencana dan penataan permukiman perkotaan.

Berdasarkan uraian di atas, maka pertanyaan yang dirumuskan dalam penelitian ini antara lain:

1. Bagaimana sebaran permukiman kumuh di Kota Bekasi?
2. Bagaimana tingkat sensitivitas dan kapasitas adaptif permukiman kumuh di Kota Bekasi terhadap bencana banjir dan kebakaran secara spasial?

Adapun tujuan penelitian ini secara umum yaitu menginformasikan tingkat sensitivitas dan kapasitas adaptif terhadap bencana banjir dan kebakaran sebagai bahan pertimbangan pemangku kepentingan dalam menyusun konsep penataan permukiman kumuh didasarkan atas kondisi lingkungan dan kesiapan bencana di Kota Bekasi.

Sebaran Permukiman Kumuh

Hasil interpretasi foto udara pada dengan menggunakan variabel kepadatan rumah dan tata letak serta data sekunder dengan menggunakan variabel kondisi sanitasi dan jumlah penghuni, mengidentifikasi 155 permukiman kumuh di Kota Bekasi yang tersebar di 12 kecamatan dan 24 kelurahan.

Permukiman kumuh yang ada di Kota Bekasi memiliki luas 0,19% dari total luas wilayah kota dengan permukiman kumuh terbanyak berada di Kecamatan Bantargebang yaitu 37,3% dari total luas permukiman kumuh. Besarnya luasan permukiman kumuh di dserah tersebut disebabkan keberadaan Tempat Pembuangan Akhir (TPA) Bantargebang yang menjadi lokasi pembuangan sampah dari masyarakat Propinsi DKI Jakarta yang terus meningkat volumenya dari tahun ke tahun sehingga menjadi daya tarik penduduk untuk tinggal di sekitarnya dan bekerja sebagai pemulung.

Kualitas Permukiman Kumuh

Berdasarkan hasil penilaian dengan variabel-variabel kepadatan rumah, tata letak, sanitasi dan jumlah penghuni diperoleh bahwa permukiman kumuh di Kota Bekasi didominasi oleh kepadatan rumah dengan kategori berat (kepadatan rumah 40-70%) sebesar 48,48%, tata letaknya semi teratur (40-60% rumah seragam arah hadap) sebesar 59,35%, sarana sanitasinya didominasi oleh penggunaan MCK umum, dan kebanyakan jumlah penghuni dalam satu rumah sebanyak 5-8 orang yaitu sebesar 58,06%. Permukiman-permukiman kumuh yang ada di 12 kecamatan di Kota Bekasi umumnya memiliki kualitas kumuh berat dengan luas 253.168 m^2 atau 62% dari luas permukiman kumuh yang ada di Kota Bekasi. Permukiman kumuh kualitas berat dengan luas terbesar berada di Kecamatan Bantargebang yaitu di Kelurahan Ciketing Udik dan Kelurahan Cikiwul Permukiman kumuh dengan kualitas berat umumnya tersebar di sekitar komplek perumahan, sekitar daerah komersil, sempadan sungai dan sempadan rel kereta. Namun permukiman kumuh kualias berat cenderung terkonsentrasi di sekitar TPA Bantargebang di Kelurahan Ciketing Udik dan Kelurahan Cikiwul dan di sekitar daerah pertanian/RTH Kelurahan Pekayon Jaya yang berdekatan dengan TPS.

Pada bagian utara Kota Bekasi (berada di sebelah utara jalan tol yang membujur di tengah Kota Bekasi), umumnya permukiman kumuh dengan kualitas berat berada di sekitar daerah pertanian/RTH, sekitar daerah komersil, sempadan sungai dan sempadan rel kereta. Keberadaan permukiman kumh dengan kualitas berat ini dipengaruhi oleh kebutuhan lahan kosong untuk tempat tinggal yang terjangkau ke pusat ekonomi sebagai tujuan bekerja meskipun dengan ancaman bencana dan kecelakaan yang cukup tinggi (khususnya di sempadan sungai dan sempadan rel kereta api). Sedangkan pada bagian selatan Kota Bekasi, permukiman kumuh kualitas berat terdapat di sekitar daerah komersil dan sekitar TPA. Meskipun perkembangan bagian selatan Kota Bekasi tidak sepesat bagian utara dengan kemudahan aksesibilitasnya (keberadaan jalan tol, jalan arteri dan rel kereta api), namun keberadaan TPA Bantargebang sebagai lokasi pembuangan akhir sampah dari Propinsi DKI Jakarta menjadi daya tarik penduduk untuk bermukim di sekitarnya untuk bekerja sebagai pemulung sampah.

Permukiman kumuh dengan kualitas sedang juga tersebar merata di seluruh kota, dengan beberapa konsentrasi di sekitar daerah pertanian/RTH di Kelurahan Bintara dan Kelurahan Jatiasih, di sekitar komplek perumahan Kelurahan Jatiwaringin, Kelurahan Jatiasih dan Kelurahan Jati Melati dan di sekitar daerah komersil di Kelurahan Margahayu, Kelurahan Kayuringin dan Kelurahan Pekayon Jaya. Kualitas sedang cenderung tersebar di bagian tengah Kota Bekasi yaitu disekitar jalan tol dan jalan arteri. Dengan kemudahan aksesibilitas tersebut maka pusat perekonomian dan fasilitas umum terkonsentrasi di sekitarnya sehingga menarik minat masyarakat golongan bawah untuk mendiami lahan-lahan kosong di dekat tempat kerja meskipun dengan kondisi lingkungan yang marjinal.

Distribusi permukiman kumuh dengan kualitas rendah di Kota Bekasi terkonsentrasi di sekitar kompleks perumahan Kelurahan Jatimurni dan di sekitar daerah pertanian/RTH Kelurahan Jatiasih. Berkembangnya permukiman kumuh kualitas rendah hanya di bagian selatan kota yang memiliki daya tarik yang rendah terutama dalam sektor ekonomi akibat tingkat aksesibilitasnya tidak semudah bagian utara Kota Bekasi yang memiliki berbagai alternatif prasarana transportasi dan fasilitas umum, disebabkan oleh motivasi masyarakat golongan bawah yang tinggal disana tidak semata-mata mendekati pusat-pusat perekonomian sebagai tempat kerja namun karena alasan mengikuti keluarga. Umumnya masyarakat yang tinggal di permukiman kumuh dengan kualitas rendah merupakan penduduk lokal (penduduk asli Kota Bekasi).

Karakteristik Tipologi Permukiman Kumuh

Hasil identifikasi menunjukkan bahwa permukiman kumuh di Kota Bekasi tersebar di beberapa tempat yang memiliki karakteristik sejenis. Permukiman kumuh tersebut antara lain berada di sempadan sungai, sempadan rel kereta, sekitar daerah pertanian/ RTH, sekitar kompleks perumahan, sekitar daerah komersil dan sekitar TPA.

Terdapat 31 permukiman kumuh yang berada di sempadan sungai yang tersebar di Kelurahan Pejuang, Kelurahan Kaliabang Tengah, Kelurahan Harapan Jaya, Kelurahan Kayuringin Jaya, Kelurahan Pekayon Jaya, Kelurahan Margahayu dan Kelurahan Bekasi Jaya.

Hasil observasi dan kuisioner kepada para responden menunjukkan bahwa rumah di permukiman kumuh sempadan sungai merupakan rumah sewa dengan beberapa diantaranya merupakan rumah pribadi, dengan kondisi semi permanen, dihuni rata-rata oleh 2-8 orang atau1-2 KK per rumah, air tanah sebagai sumber air bersih, memiliki MCK pribadi namun juga menggunakan MCK umum (Lampiran 8). Rumah-rumah di tipologi ini memiliki kondisi drainase yang relatif lancar, sampah dibakar dan ada juga yang dibuang langsung ke sungai, pelanggan PLN secara kolektif dengan tetangga, memiliki kondisi kabel listrik rumah yang tidak teratur dan masyarakat menetap di permukiman kumuh tersebut ada yang kurang dari 10 tahun dan ada pula yang lebih dari 10 tahun.

Masyarakat yang tinggal di permukiman kumuh merupakan para pendatang dari Jawa Tengah dengan pendidikan terakhir yang diikuti adalah pendidikan dasar. Motivasi pindah rata-rata untuk mencari penghasilan yang lebih baik di kota besar dengan cara ikut saudara, akibat sulitnya mendapatkan uang yang cukup di daerah asal. Umumnya mereka bekerja sebagai pedagang keliling dan pemulung dengan pendapatan yang diperoleh per hari dibawah Upah Minimum Regional (UMR) Kota Bekasi.

Permukiman kumuh di daerah ini rata-rata selalu mengalami banjir setiap tahunnya namun tidak ada korban jiwa dan ada yang pernah mengalami kebakaran. Komunitas masyarakat sebagai media komunikasi untuk menginformasikan metode penanggulangan bencana yang dapat dilakukan oleh masyarakat berjalan aktif, namun di beberapa permukiman kumuh tidak ada komunitas masyarakat yang aktif.

Permukiman kumuh yang berada di sempadan rel kereta terdistribusi di 5 permukiman kumuh yang berada di Kelurahan Bekasi Jaya dan Kelurahan Bekasi Baru sebagai daerah yang dilalui jalur kereta. Berdasarkan hasil observasi dan kuisioner kepada para responden, rumah-rumah di permukiman kumuh sempadan rel kereta merupakan rumah sewa, dengan kondisi semi permanen, dihuni rata-rata oleh 4-8 orang atau 1-4 KK per rumah, air tanah sebagai sumber air bersih dan tidak memiliki MCK pribadi (menggunakan MCK umum). Adapun kondisi drainasenya rata-rata relatif tersumbat dan memiliki tempat pembuangan sampah pribadi meskipun tidak mencukupi namun beberapa masyarakatnya langsung membuang sampah ke sungai. Merupakan pelanggan PLN secara kolektif dengan tetangga, kondisi kabel listrik di dalam rumah tidak teratur dan telah mendiami permukiman kumuh ini ada yang kurang dari 10 tahun dan ada pula yang lebih dari 10 tahun. Masyarakat yang tinggal umumnya merupakan penduduk dari luar Kota Bekasi (pendatang dari Jawa Tengah) yang memiliki motivasi datang ke pusat kota dengan alasan ikut keluarga. Rata-rata tingkat pendidikan terakhir yang dimiliki pendidikan dasar dan bermatapencaharian sebagai pemulung dengan pendapatan yang per hari masih dibawah UMR, meskipun ada juga yang memiliki pendapatan diatas UMR Kota Bekasi.

Permukiman-permukiman kumuh di sempadan rel kereta tidak pernah mengalami riwayat kejadian banjir maupun kebakaran. Komunitas masyarakat sebagai media komunikasi untuk menginformasikan metode penanggulangan bencana yang dapat dilakukan oleh masyarakat berjalan aktif

Berdasar identifikasi, terdapat 27 permukiman kumuh yang berada di sekitar daerah pertanian/RTH. Kecenderungan persebaran berada di Kelurahan Pekayon Jaya dan Jatiasih. Hasil observasi dan kuisioner kepada para responden menyimpulkan bahwa umumnya rumah-rumah di permukiman kumuh di sekitar daerah pertanian/RTH merupakan rumah sewa, dengan kondisi rumah sebagian tidak permanen (terbuat dari material triplek dan bambu) dan sebagian lain memiliki kondisi semi permanen (perpaduan dari material batu bata dan triplek). Rata-rata tiap rumah dihuni oleh 5-8 orang atau 1-3 KK, menggunakan air tanah sebagai sumber air bersih dan menggunakan MCK umum (tidak memiliki MCK pribadi). Kondisi drainase tersumbat, tidak memiliki tempat pembuangan sampah pribadi, pelanggan PLN secara kolektif dengan tetangga, memiliki kondisi kabel listrik dalam rumah umumnya tidak teratur namun ada juga yang teratur rapi. Masyarakat telah mendiami permukiman kumuh ini umumnya telah lebih dari 10 tahun. Masyarakat permukiman kumuh di sekitar daerah pertanian/RTH adalah penduduk asli Bekasi dan sekitarnya. Tingkat pendidikan terakhir yang ditempuh rata-rata hanya sampai pendidikan dasar. Adapun motivasi masyarakat menempati permukiman kumuh ini selain karena dekat dengan lokasi kerja, ada pula karena ikut keluarga. Umumnya mereka bekerja sebagai pembantu dan pemulung dengan pendapatan yang diperoleh per hari diatas UMR Kota Bekasi, namun ada juga yang memiliki pendapatan dibawah UMR Kota Bekasi. Rumah-rumah kumuh di daerah ini sering mengalami banjir dan pernah mengalami kebakaran. Komunitas masyarakat sebagai media komunikasi untuk menginformasikan metode penanggulangan bencana yang dapat dilakukan oleh masyarakat berjalan aktif, namun di beberapa permukiman kumuh tidak ada komunitas masyarakat yang aktif.

Kota Bekasi memiliki 49 permukiman kumuh yang berada di sekitar kompleks perumahan. Keberadaannya cenderung tersebar di Kelurahan Pekayon Jaya, Kelurahan Duren Jaya, Kelurahan Aren Jaya, Kelurahan Jatiasih dan Kelurahan Jati Melati. Setelah dilakukan observasi dan kuisioner kepada para responden, diperoleh informasi rumah-rumah di permukiman kumuh di sekitar kompleks perumahan merupakan rumah sewa dengan kondisi bangunan semi permane, dihuni rata-rata oleh 3-9 orang atau 1-3 KK per rumah, menggunakan sumber air bersih berasal dari air tanah dan tidak memiliki MCK pribadi (menggunakan MCK umum). Umumnya kondisi drainasenya tersumbat, tidak memiliki pembuangan sampah pribadi (sampah dibakar), menjadi pelanggan PLN secara kolektif dengan tetangga, memiliki kondisi kabel listrik dalam rumah yang tidak teratur dan rata-rata telah menetap di permukiman kumuh ini lebih dari 10 tahun.

Masyarakat yang tinggal berasal dari Bekasi dan sekitarnya (penduduk lokal) dengan rata-rata hanya menempuh pendidikan dasar sebagai pendidikan terakhir. Adapun motivasi masyarakat untuk memilih tinggal di permukiman kumuh ini umumnya karena ikut keluarga. Pekerjaan masyarakatnya didominasi sebagai pemulung dengan pendapatan harian masih dibawah UMR Kota Bekasi.

Permukiman kumuh di daerah ini tidak pernah mengalami kejadian banjir, namun pernah mengalami kebakaran yang tidak memakan korban jiwa. Komunitas masyarakat sebagai media komunikasi untuk menginformasikan metode penanggulangan bencana yang dapat dilakukan oleh masyarakat berjalan aktif, namun di beberapa permukiman kumuh tidak ada komunitas masyarakat yang aktif.

Di sekitar beberapa daerah komersil Kota Bekasi, terdapat 32 permukiman kumuh. Permukiman kumuh tipologi ini lebih banyak tersebar di Kelurahan Kayuringin Jaya, Kelurahan Pekayon Jaya, Kelurahan Margahayu, Kelurahan Jatiasih dan Kelurahan Jati Sampurna. Hasil observasi dan kuisioner kepada para responden menunjukkan bahwa masyarakat yang tinggal di permukiman kumuh sekitar daerah komersil menempati rumah sewa, dengan kondisi bangunan semi permanen dan rata- rata dihuni oleh 3-5 orang atau 1-2 KK per rumah. Sumber air bersih yang digunakan berasal dari air sumur, beberapa rumah memiliki MCK pribadi sedangkan yang tidak memilikinya menggunakan MCK umum, kondisi drainase tersumbat, tempat pembuangan sampah pribadi dimiliki oleh beberapa rumah namun banyak juga yang tidak memiliki tempat pembuangan sampah. Beberapa rumah menjadi pelanggan PLN secara pribadi, namun banyak pula yang menjadi pelanggan PLN secara kolektif dengan tetangga. Kondisi kabel listrik dalam rumah sebagian besar teratur rapi dan lainnya lagi tidak teratur. Umumnya masyarakat tinggal di permukiman kumuh ini lebih dari 10 tahun.

Asal masyarakat yang tinggal disini, sebagian merupakan pendatang dan sebagian lagi penduduk asli Bekasi dan sekitarnya. Pendidikan dasar juga menjadi pendidikan terakhir rata-rata penduduk di permukiman kumuh ini sama seperti tipologi sebelumnya. Motivasi masyarakat menempati permukiman kumuh di sekitar daerah komersil ini yaitu kedekatan lokasi dengan tempat kerja. Umumnya mereka bekerja sebagai buruh dan kuli dengan rata-rata pendapatan per hari masih dibawah UMR Kota Bekasi, namun ada juga yang memiliki pendapatan diatas UMR Kota Bekasi. Bencana banjir sering terjadi di daerah ini namun tidak memakan korban jiwa. Sedangkan kejadian kebakaran belum pernah terjadi pada permukiman kumuh ini. Komunitas masyarakat sebagai media komunikasi untuk menginformasikan metode penanggulangan bencana yang dapat dilakukan oleh masyarakat berjalan juga aktif.

F. Permukiman kumuh di sekitar TPA

Permukiman kumuh di sekitar TPA terkonsentrasi di Kelurahan Ciketing Udik dan Kelurahan Cikiwul sebagai lokasi TPA Bantargebang. Terdapat 11 permukiman kumuh pada wilayah tersebut. Masyarakat permukiman kumuh yang tinggal di sekitar TPA umumnya menempati rumah sewa dengan kondisi tidak permanen dan dihuni rata-rata oleh 3-9 orang atau 1-3 KK per rumah. Kebutuhan air bersih diperoleh dari air tanah, umumnya mereka tidak memiliki MCK pribadi (menggunakan MCK umum) dan kondisi drainasenya tersumbat. Dalam memenuhi kebutuhan listrik, umumnya masyarakat menjadi pelanggan PLN secara kolektif dengan tetangga. Kondisi kabel dalam rumah rata-rata tidak teratur. Masyarakat telah tinggal di permukiman kumuh ini umumnya lebih dari 10 tahun.

Daerah asal masyarakat yang tinggal di permukimah kumuh sekitar TPA umumnya dari sekitar Bekasi (penduduk lokal) dengan pendidikan terakhir hanya sampai pendidikan dasar. Selain karena ikut keluarga, alasan sulit mendapatkan uang di daerah asal menjadi motivasi utama masyarakat tinggal di permukiman kumuh ini. Bekerja sebagai pemulung menjadi dominasi jenis mata pencaharian meskipun pendapatan yang diperoleh per hari masih dibawah UMR Kota Bekasi.

Permukiman kumuh di daerah ini setiap tahun mengalami banjir dan pernah mengalami kebakaran namun tidak memakan korban jiwa. Komunitas masyarakat sebagai media komunikasi untuk menginformasikan metode penanggulangan bencana yang dapat dilakukan oleh masyarakat berjalan dengan aktif. Lokasi rumah mempengaruhi kualitas hidup dan lingkungan penghuninya. Ini dapat dilihat dari kualitas lingkungan di permukiman kumuh pada tipologi sekitar TPA dan sekitar daerah pertanian/RTH yang memiliki kualitas paling buruk dibandingkan dengan permukiman kumuh pada tipologi lainnya. Rumah-rumah di tipologi tersebut memiliki kondisi bangunan tidak permanen (berbahan triplek atau bambu atau kayu) yang mudah terimbas bahaya bila terjadi bencana banjir atau kebakaran akibat minimnya kekuatan bangunan. Selain itu juga tergolong kurang layak huni ditinjau dari jumlah penghuninya. Umumnya rumah pada tipologi tersebut dihuni oleh 5 sampai 9 orang dengan luas rumah rata-rata 15-25 meter^2. Meskipun kualitas hidup rendah dan tingkat pendapatan yang diperoleh juga rendah, namun minat masyarakat untuk tinggal di tipologi ini tetap tinggi karena ruang kosong yang tersedia lebih luas dibandingkan tipologi lainnya dan tidak perlu bersusah payah mencari pekerjaan. Cukup dengan memilah sampah yang berada di sekitar rumah.

Masyarakat yang tinggal di tipologi sekitar daerah komersil dan sempadan kereta umumnya memiliki tingkat kesejahteraan yang lebih tinggi ditinjau dari segi pendapatan. Kemampuan ekonomi yang rendah mendesak masyarakat golongan lemah untuk memilih tinggal di sela-sela ruang kosong di pusat-pusat kota meskipun dengan kondisi yang tidak layak. Selain disebabkan rendahnya kemampuan untuk memperoleh rumah tinggal yang layak, juga bertujuan mendekati tempat kerja sehingga meminimalkan biaya transportasi.

Tingkat Sensitivitas dan Kapasitas Adaptif

Data-data hasil observasi dan kuisioner pada variabel-variabel untuk mengukur tingkat sensitivitas dan kapasitas adaptif pada permukiman kumuh terhadap bencana banjir dan kebakaran diolah dengan pemberian kriteria untuk penilaian pada hasil dan bobot dari para pakar pada masing-masing variabel untuk mendapatkan sebaran tingkat sensitivitas dan kapasitas adaptif secara spasial.

Berdasarkan hasil pengolahan data, terdapat 111 permukiman kumuh yang memiliki tingkat sensitivitas rendah terhadap banjir yang didominasi oleh permukiman kumuh dengan tipologi di sekitar kompleks perumahan. Rendahnya sensitivitas terkait dengan jarak dari rumah terhadap sungai yang cukup jauh (diluar batas sempadan sungai). Permukiman kumuh dengan tingkat sensitivitas tinggi terhadap banjir berjumlah 44 permukiman kumuh yang termasuk tipologi permukiman kumuh di sempadan sungai. Dengan letak rumah di pinggir sungai (kurang dari 10 meter) maka rumah-rumah pada tipologi ini akan cenderung terdampak banjir bila volume air sungai meningkat.

Terdapat 81 permukiman kumuh yang memiliki tingkat kapasitas adaptif rendah terhadap banjir yang didominasi oleh permukiman kumuh dengan tipologi di sekitar kompleks perumahan. Penyebab rendahnya kapasitas adaptif yaitu tidak adanya komunitas masyarakat yang bergerak aktif sebagai sarana media informasi dari stakeholder atau pemerintah dalam kampanye pencegahan dan penanggulangan bencana. Tingkat kapasitas adaptif yang tinggi terhadap banjir berjumlah 74 permukiman kumuh dengan dominasi tipologi di sempadan sungai. Meskipun permukiman kumuh di sempadan sungai memiliki tingkat sensitivitas yang tinggi terhadap banjir, namun juga memiliki tingkat kapasitas adaptif yang tinggi terhadap banjir karena faktor keaktifan komunitas masyarakat sebagai media penyampaian informasi pencegahan dan penanggulangan bencana.

Permukiman kumuh yang memiliki tingkat sensitivitas terhadap banjir rendah dan tingkat kapasitas adaptif terhadap banjir juga rendah berjumlah 63 permukiman kumuh. Letak permukiman kumuh yang memiliki nilai tersebut berada di sekitar TPA. Hal ini diperoleh dari prosentase permukiman kumuh di sekitar TPA yang memiliki tingkat sensitivitas dan adaptif rendah, dibandingkan dengan jumlah total permukiman kumuh yang termasuk ke dalam tipologi ini. Rendahnya sensitivitas dan kapasitas adaptif dipengaruhi oleh besarnya jarak dari rumah terhadap sungai serta besarnya jarak dari rumah terhadap fasilitas kesehatan sehingga apabila memerlukan pertolongan medis saat terjadi bencana akan lebih cepat teratasi. Terdapat 48 permukiman kumuh dengan tingkat sensitivitas terhadap banjir rendah namun kapasitas adaptif terhadap banjir tinggi. Prosentase terbesar dibandingkan dengan jumlah tipologinya, terdapat pada permukiman kumuh di sekitar daerah pertanian/RTH. Kondisi ini dipengaruhi oleh jarak dari sungai yang relatif jauh dan adanya komunitas masyarakat yang aktif serta kedekatan jarak rumah terhadap fasilitas

Terdapat 18 permukiman kumuh yang memiliki tingkat sensitivitas terhadap banjir tinggi namun tingkat kapasitas adaptif terhadap banjir rendah. Permukiman kumuh yang memiliki tingkatan tersebut berada di sempadan sungai. Penyebab jenis tipologi ini masuk ke dalam tingkatan tersebut, karena memiliki jarak dengan sungai sangat dekat (kurang dari 10 meter) dan tidak adanya komunitas masyarakat yang aktif. Sedangkan permukiman kumuh yang memiliki sensitivitas terhadap banjir tinggi dan kapasitas adaptif terhadap banjir juga tinggi berjumlah 26 permukiman kumuh. Umumnya terdapat di sempadan sungai. Tingginya sensitivitas namun tinggi pula kapasitas adaptifnya diperoleh dari minimnya jarak dengan sungai, namun memiliki komunitas masyarakat yang aktif dan memiliki jarak ke fasilitas kesehatan yang terjangkau (berjarak kurang dari 1500 meter).

Permukiman kumuh yang memiliki tingkat sensitivitas rendah terhadap kebakaran berjumlah 50 permukiman kumuh yang lebih banyak terdapat di sekitar kompleks perumahan. Tingginya sensitivitas disebabkan rumah- rumah pada tipologi ini memiliki usia bangunan diatas 10 tahun yang mengindikasikan ketidakteraturan kondisi kabel listrik sehingga kejadian korsleting listrik sebagai salah satu pemicu kebakaran akan lebih mudah terjadi. Adapun permukiman kumuh dengan tingkat sensitivitas tinggi terhadap kebakaran berjumlah 105 permukiman kumuh yang juga banyak terdapat di sekitar kompleks perumahan. Kesamaan tipologi antara permukiman kumuh yang memiliki tingkat sensitivitas rendah dan tinggi terhadap kebakaran, disebabkan karena sebagian permukiman kumuh di sekitar kompleks perumahan Kota Bekasi memiliki usia bangunan kurang dari 10 tahun. Dengan usia bangunan yang relatif muda, kondisi kabel listrik di dalam rumah dikategorikan teratur sehingga tidak sensitif terhadap bahaya kebakaran

Tingkat kapasitas adaptif permukiman kumuh terhadap kebakaran sama nilainya dengan tingkat kapasitas adaptif permukiman kumuh terhadap banjir. Sejumlah 81 permukiman kumuh memiliki kapasitas adaptif yang rendah terhadap kebakaran yang didominasi oleh permukiman kumuh di sekitar kompleks perumahan. Permukiman kumuh dengan kapasitas adaptif tinggi berjumlah 74 permukiman kumuh. Letak permukiman kumuh yang memiliki kapasitas adaptif tinggi terhadap kebakaran sebagian besar berada di sempadan sungai.

Kesamaan nilai hasil analisis antara kapasitas adaptif terhadap banjir dan terhadap kebakaran, disebabkan sebagian besar jenis variabelnya sama. Hanya terdapat satu variabel yang berbeda, yaitu variabel sumber air bersih pada kapasitas adaptif terhadap banjir dan variabel keberadaan hidran pada kapasitas adaptif terhadap kebakaran. Kedua variabel ini sama-sama memiliki kriteria nilai terendah. Selain itu para pakar juga memberikan proporsi bobot yang hampir sama antara variabel-variabel untuk kapasitas adaptif terhadap banjir dan kapasitas adaptif terhadap kebakaran.

Permukiman kumuh dengan tingkat sensitivitas terhadap kebakaran rendah dan kapasitas adaptif terhadap kebakaran rendah berjumlah 17 permukiman kumuh. Prosentase terbesar terdapat pada permukiman kumuh di sempadan rel kereta. Penyebab permukiman kumuh di sempadan rel kereta memiliki tingkat sensitifitas dan kapasitas adaptif yang sama rendah, yaitu karena rumah-rumah pada permukiman kumuh ini memiliki kondisi bangunan semi permanen dan usia bangunan kurang dari 10 tahun, namun tidak terdapat komunitas masyarakat yang aktif. Terdapat 33 permukiman kumuh dengan tingkat sensitivitas terhadap kebakaran rendah tetapi kapasitas adaptif terhadap kebakaran tinggi. Dominasinya juga terdapat di sempadan rel kereta.

Permukiman kumuh dengan tingkat sensitivitas terhadap kebakaran tinggi namun kapasitas adaptif terhadap kebakaran rendah berjumlah 64 permukiman kumuh. Tingkatan ini didominasi permukiman kumuh di sekitar TPA. Penyebabnya yaitu kondisi bangunan yang tidak permanen dan usia bangunan lebih dari 10 tahun yang diasumsikan kondisi kabel listrik juga tidak terawat (mudah terjadi korsleting listrik sebagai pemicu kebakaran), namun memiliki jarak yang jauh dari fasilitas kesehatan. Sedangkan permukiman kumuh yang memiliki sensitivitas terhadap kebakaran tinggi dan kapasitas adaptif terhadap kebakaran juga tinggi berjumlah 41 permukiman kumuh yang banyak terdapat di sempadan sungai. Ini terjadi karena pada rumah-rumah pada permukiman kumuh tersebut rata-rata memiliki usia bangunan diatas 10 tahun, namun memiliki komunitas masyarakat yang aktif dan jarak ke fasilitas kesehatan yang terjangkau (berjarak kurang dari 1500 meter).

Permukiman kumuh dengan tingkat sensitivitas yang rendah terhadap banjir dan kebakaran tersebar di sekitar daerah pertanian/RTH, di sekitar kompleks perumahan, di sempadan rel kereta dan di sekitar daerah komersil (Gambar 5.22). Hasil pengolahan data menunjukkan dari 32 permukiman kumuh yang tingkat sensitivitasnya rendah terhadap banjir dan kebakaran, 14 permukiman kumuhnya berada di sekitar kompleks perumahan. Permukiman kumuh ini terpusat di Kelurahan Duren Jaya, Kelurahan Bojong Rawalumbu dan Kelurahan Jatiasih. Tingkat sensitivitas yang tinggi terhadap banjir dan kebakaran terkonsentrasi pada permukiman kumuh di sempadan sungai. Distribusi permukiman kumuh di sempadan sungai yang tinggi sensitivitasnya terhadap banjir dan kebakaran berada di Kelurahan Jatikramat, Kelurahan Jati Mekar, Kelurahan Margahayu dan Kelurahan Pejuang.

Adapun permukiman kumuh yang memiliki tingkat kapasitas adaptif rendah terhadap banjir dan kebakaran terdistribusi di seluruh tipologi permukiman kumuh yang ada di Kota Bekasi (Gambar 5.23). Pusat distribusi berada pada permukiman kumuh di sekitar kompleks perumahan, yaitu berjumlah 27 permukiman kumuh dari 81 permukiman kumuh yang masuk ke tingkat kapasitas adaptif rendah. Distribusi daerahnya berada di Kelurahan Bojong Rawalumbu, Kelurahan Pekayon Jaya, Kelurahan Jatiasih, Kelurahan Jati Murni dan Kelurahan Jatiasih. Terdapat 74 permukiman kumuh yang memiliki tingkat kapasitas adaptif tinggi terhadap banjir dan kebakaran. Dominasinya berada pada permukima kumuh di sempadan sungai yang termasuk wilayah Kelurahan Bekasi Jaya,

1. Permukiman kumuh di Kota Bekasi berjumlah 155 permukiman kumuh yang tersebar di sempadan sungai, sempadan rel kereta, sekitar daerah pertanian/RTH, sekitar kompleks perumahan, sekitar daerah komersil dan sekitar TPA;
2. Terkait dengan mitigasi kebencanaan pada permukiman kumuh, maka peninjauan sensitivitas pada tingkat terendah dan peninjauan kapasitas adaptif pada tingkat tertinggi. Permukiman kumuh dengan tingkat sensitivitas tinggi dan kapasitas adaptif terhadap rendah terhadap banjir terkonsentrasi di sempadan sungai. Tingkat sensitivitas tinggi dan kapasitas adaptif rendah terhadap kebakaran terpusat pada permukiman kumuh di sekitar TPA.

Mengembangkan Metode untuk Mengkarakterisasi Sejarah Penggunaan Lahan dengan Menggunakan Data Deret Waktu Landsat sebagai Metode Deteksi Dini Lahan Terbengkalai di Indonesia

Developing a Method to Characterize Land Use History Using Landsat Time Series as an Idle Land Early Detection Method In Indonesia

Nama	: Marthalina Indhawati
NIP	: 198403052009032005
Instansi	: BPN
Tahun Intake	: 2013
Tingkat Beasiswa	: Master Overseas
Program Studi	: Master of Science Programme Geo-Information Science
Negara Studi	: Belanda
Universitas	: Wageningen University

// ABSTRAK

Dalam penelitian ini, kami menyediakan metode yang memungkinkan untuk melakukan inventarisasi lahan menganggur yang ditunjukkan berdasarkan metode penginderaan jauh dimana kami bertujuan: 1) untuk mengetahui apakah ada pembebasan lahan/penggundulan hutan di bidang tanah HGU atau tidak dan 2) untuk menemukan apa adalah tutupan lahan HGU, empat tahun setelah penerbitan regulasi pengendalian lahan menganggur dan bandingkan, apakah itu sama dengan tujuan hak tersebut. Pertama, kami menggunakan citra satelit Landsat untuk tahun 2008 sampai 2014 dan menerapkan *Break For Additive Season dan Trend Monitor (*BFAST Monitor) dengan periode pemantauan dari tanggal 1 Januari 2013 sampai 1 Juli 2014 untuk mendeteksi perubahan spasial dan temporal untuk lima paket tanah HGU di Provinsi Riau - Indonesia. Kami menggabungkan titik balik dan menetapkan ambang batas 0, -0,025, -0,05, -0,075, -0,1 untuk nilai besarnya untuk mengevaluasi ambang batas mana yang akan mendapatkan akurasi terbaik dalam mendeteksi pembukaan lahan untuk lima area studi. Kami memvalidasi hasil pemantauan BFAST kami, dengan menggunakan gambar SPOT 6 tahun 2013 dan 2014. Tujuan dari validasi ini adalah untuk memvalidasi, keakuratan monitor BFAST dalam mendeteksi pembukaan lahan. Kami memilih titik silang antara akurasi pengguna dan produsen sebagai estimator yang tidak bias untuk mendapatkan ambang terbaik untuk mendeteksi pembukaan lahan untuk setiap area studi. Secara umum, ambang batas -0,075 memberikan hasil terbaik dalam deteksi pembukaan lahan untuk area studi khusus ini. Nilai ambang ini sesuai dengan akurasi keseluruhan tertinggi yaitu 88,24%. Kami menyimpulkan bahwa BFAST Monitor dapat digunakan untuk mendeteksi pembukaan lahan di lima paket tanah HGU dengan menggabungkan nilai breakpoint dan magnitude. Kedua, kami melakukan klasifikasi supervisi maksimum untuk gambar Landsat 8 menggunakan citra SPOT 6 yang diperoleh pada tanggal 17 Juni 2014 sebagai dasar kebenaran untuk mengamati tutupan lahan yang ada. Kami memvalidasi hasil klasifikasi kami dengan menggunakan gambar SPOT 6 untuk tahun 2014 dalam kombinasi dengan peta tutupan lahan Kampar pada tahun 2014. Kami melakukan pengambilan sampel acak dan menggabungkan hasilnya menjadi satu matriks kebingungan untuk lima area studi. Hasil penilaian akurasi ini menunjukkan akurasi keseluruhan 86,13% dan koefisien Kappa sebesar 0,78, yang sesuai dengan kesepakatan substansial. Kami menyimpulkan bahwa mendeteksi tanah kosong lebih akurat daripada vegetasi yaitu kelapa sawit, hutan, dan padang rumput. Secara umum dapat disimpulkan bahwa rangkaian waktu Landsat cocok digunakan untuk deteksi dini lahan idle. Namun, tutupan awan tinggi merupakan aspek utama yang menyebabkan ketersediaan data rendah, yang membatasi kegunaan metodologi kami.

Kata kunci: lahan kosong, *Landsat, time series*, BFAST Monitor, klasifikasi tutupan lahan, Indonesia.

ABSTRACT

In this study we provide a possible method for performing indicated idle land inventory based on remote sensing methods in which, we aimed: 1) to find out whether there is any land clearance/deforestation on HGU land parcels or not and 2) to find what is the HGU land cover, four years after the publication of idle land controlling regulation and compare, whether it is the same as the purpose of the entitlement. Firstly, we used Landsat satellite images for the years 2008 until 2014 and applied the Break For Additive Season and Trend Monitor (BFAST Monitor) with a monitoring period from the 1^{st} of January 2013 to the 1^{st} of July 2014 to detect spatial and temporal changes for five HGU land parcels in the Riau Province – Indonesia. We combined the breakpoints and set a threshold of 0, -0.025, -0.05, -0.075, -0.1 for the magnitude value to evaluate which threshold would obtain the best accuracy in detecting land clearance for the five study areas. We validated our BFAST monitor results, by using SPOT 6 images of the years 2013 and 2014. The purpose of this validation was to validate, the accuracy of the BFAST monitor in detecting land clearance. We chose the cross point between user's and producer's accuracy as an unbiased estimator in order to get the best threshold for detecting land clearance for each study area. In general, a magnitude threshold of -0.075 gave the best results in land clearance detection for this particular study area. This threshold value corresponded to the highest overall accuracy of 88.24%. We concluded that the BFAST Monitor could be used for detecting land clearance in the five HGU land parcels by combining breakpoints and magnitude values. Secondly, we performed a maximum likelihood supervised classification for a Landsat 8 image using a SPOT 6 image acquired on 17 June 2014 as the ground truth for observing the existing land cover. We validated our classification results by using a SPOT 6 image for the year 2014 in combination with the Kampar land cover map of the year 2014. We performed random sampling and combined the results into one confusion matrix for the five study areas. The results of this accuracy assessment showed an overall accuracy of 86.13% and a Kappa coefficient of 0.78, which corresponds to a substantial agreement. We concluded that detecting bare soil is more accurate than vegetation i.e. oil palm, forest, and grassland. In general, it can be concluded that Landsat time series are suitable to be used for idle land early detection. However, high cloud cover was a major aspect causing a low data availability, which limited the usability of our methodology.

Keywords: idle land, Landsat, time series, BFAST Monitor, land cover classification, Indonesia.

Based on the indicated idle land inventory, the NLA targeted 1656 objects for idle land controlling in the period 2011 until 2013, which corresponded to about 3.5 million hectare indicated idle land all over Indonesia. However, until 2014, the idle land controlling still cannot reach maximum result. Until March 2014, only 104 land parcels out of the total of 1656 objects were determined as idle land, which corresponded to 68,969.85 hectare. Many obstacles appear during this process, both during the indicated idle land inventory as well as during the idle land controlling itself. Some of those obstacles occur because of lack of understanding about the existing regulations and inaccurate objects of idle land controlling. The indicated idle land inventory will be the source to determine the object of idle land controlling, which needs a good planning for both budget and human resources. Therefore, the NLA should put more attention in indicated idle land inventory. However, indicated idle land inventory has its own obstacle because most of land rights, especially HGU, are located at inland areas far away from the capital city. This means that a lot of budget and human resources are necessary to perform the inventory.

The new technologies have the possibility to solve these obstacles and remote sensing might be the answer to these obstacles. Remote sensing has been used successfully for many years in detection of changes (Lu et al., 2004) and time series analysis by using remote sensing techniques will give better understanding about land surface and land use changing (Herold et al., 2006; Yang and Lo, 2002). The new technologies in combination with the fast developments in the field of remote sensing also can be used to support oil palm plantation management. It is beneficial for oil palm planter to monitor characteristics of oil palm plantation for instance the phenology of oil palm (Ibrahim et al., 2001). Moreover, remote sensing is considered as a more reliable, timeliness and low cost data collection technique than sample field surveys for oil palm planning and management (Jusoff, 2009). Some studies have been performed to monitor oil palm plantations in Indonesia. Santoso et al. (2011) used QuickBird satellite images to detect the basal stem rot disease and its spatial pattern in oil palm plantations in North Sumatra. They used six vegetation indices derived from visible and near infrared bands (NIR) to identify palms infected by the disease. Sunaryathy et al. (2010) used Moderate Resolution Imaging Spectroradiometer (MODIS) to estimate Net Primary Productivity (NPP) for oil palm plantation in South Sulawesi. Another study is from Gandharum (2010), he used FORMOSAT-2 satellite images to classify growing stages of oil palms.

For idle land controlling, the NLA needs high resolution satellite imagery in order to observe land use in very accurate and detailed level. However, the high price of high-resolution satellite imagery causes that the high-resolution satellite imagery purchasing cannot be implemented every year. Therefore, free satellite imagery, e.g., Landsat, and time series of satellite images are future possibilities to support land use change monitoring and idle land early detection. Landsat satellite images have some advantages, e.g. free download (Jia et al., 2014; USGS, 2008; Xian et al., 2009) and medium spatial resolution (Maxwell et al., 2010). However, using Landsat data has also some drawbacks, like: relatively low temporal frequency and cloud cover in tropical forest areas (Hansen et al., 2009; Zhu and Woodcock, 2014). Landsat has been used for many purposes, e.g. land cover detection and classification, forest disturbance monitoring, and idle land identification (De Vries et al., 2015; Maxwell et al., 2010; Zhu and Woodcock, 2014) which used (supervised) classification and time series approach to detect the changes. Regarding change detection, the classification method is considered as an old method and is less accurate when performing land cover classification. Meanwhile, the time series approach is possible to make better understanding of the event processes. Moreover, the time series approach is capable to detect changes in near real time (Verbesselt et al., 2012; Zhu and Woodcock, 2014).

In order to perform idle land early detection, this study might be able to detect whether the HGU holder performs land clearance for areas larger than 20 hectare, in which most of HGU land cover will change from forest to bare soil. In general, this change in land cover will take place by a quick removal process. The detection of land clearance was followed by monitoring the land cover during a monitoring period. By using the 30 m spatial resolution of Landsat data, it might be difficult to detect the specific plants or utilization as mentioned in the purpose of entitlement; iit might need satellite images with a higher spatial resolution to support land cover detection. However, the presence of bare soil and grassland by the end of monitoring time indicates the HGU as an idle land.

A study performed by Maxwell et al. (2010) has determined how to detect idle land represented as bare soil using the Normalized Difference Vegetation Index (NDVI) for one year Landsat images in 2000. Their research used a classification approach that intersected the Landsat data with the California Department of Water Resources land use map. Since the research only used one year Landsat images, there was no clear description about any phenomena and process that might take place in the study area. Moreover, the term idle land in their research has some differences with the term used by the NLA. The definition of idle land by the NLA emphasis on all uses that are not used or cultivated based on the purpose of entitlement, e.g. bare soil, grassland, different plantation between the entitlement and the reality.

The publication year of idle land controlling regulation in 2010 was the starting point to monitor land cover of HGUs in Indonesia. For all HGU certificates which are published after 2010, three years after the publication of certificate is the key whether a HGU will be targeted in idle land controlling or not. Hence, all changes in this time are very important to be monitored especially the land clearance process and the existence of bare soil or grassland. Meanwhile, for all HGU certificates which were published before 2010, is still monitored by NLA and able to be targeted in idle land controlling. Therefore, land use history and existing land cover play an important role as a consideration for NLA to determine the idle land controlling target.

One of time series methods that are possible to detect abrupt changes is Breaks For Additive Seasonal and Trend (BFAST) (Verbesselt et al., 2010a). BFAST has been used to detect phenological changes in vegetation indices, droughts, and deforestation (Verbesselt et al., 2010b; Verbesselt et al., 2012; Hutchinson et al., 2015; DeVries et al., 2015) but has not yet been validated to detect land clearance in idle land controlling. Therefore, in this thesis we evaluated the capacity of BFAST to detect sudden changes related to land clearance.

The overall objectives of this thesis are to test and evaluate a Landsat based change detection method to detect land clearance, in which most of the changes will be from forest-bare soil-oil palm. The specific objectives of this thesis are:

- To find out whether there is any land clearance/deforestation on HGU land parcel or not.
- To find what is the HGU land cover, 4 years after the publication of idle land controlling regulation and compare if it is the same as the purpose of the entitlement.

The land use history and existing land cover play an important role in idle land controlling especially in indicated idle land inventory. However, the National Land Agency of the Republic of Indonesia has many obstacles in this stage. Hence, it is necessary to develop methods in which they are able to overcome those obstacles in the monitoring system of land parcels all over Indonesia. Landsat images that are free and have an adequate spatial and high temporal resolution are possible to detect changes and able to give better contribution in land cover mapping (DeVries et al., 2015; Jia et al., 2014; Zhu and Woodcock, 2014).

Observing NDVI Time Series for Land Use History

NDVI as one of vegetation indices provided by Landsat has been used for many purposes since it has strong relationship with vegetation (Pettorelli et al., 2005). An example of this relationship is that high NDVI values correspond to dense green vegetation (Bhalli et al., 2013; Myneni et al., 1997). Dutrieux et al. (2014) gives an example of an annual median NDVI time series representing a dynamic area in which dramatic forest changes occurred. In this thesis we produced annual median NDVI time series and analyzed the NDVI value to obtain important information related to land use history. Reveals that HGU D has been planted at the same year when it got the land certificate in May 2008. The rectangular pattern shows there is a plantation, which is possibly associated with oil palm as stated by CRISP (2001) and Gandharum (2010). Furthermore, by observing the relative high NDVI values, around 0.7 to 0.8, in the rectangular pattern and considering the characteristics of mature oil palm trees that are ready for harvesting 2 until 4 years after planting (Basiron, 2007), it might be concluded that the oil palm already existed before the land owner registered the HGU certificate. From legal perspective, based on the regulation of right to cultivate (Peraturan Pemerintah Republik Indonesia Nomor 40 Tahun 1996 Tentang Hak Guna Usaha, Hak Guna Bangunan dan Hak Pakai Atas Tanah - Government Regulation No. 40 Year 1996), as long as the land owner has the forest conversion certificate from Ministry of Forestry, this plantation is legal. Otherwise, the person who plants this area is indicated as breaking the law by performing a plantation on forest land. The annual dynamic median NDVI value in some area in also might be considered there is an activity in this land parcel. The both HGU B and C which were published in March 2005 and June 2007 had relative high stable NDVI values from the year 2008 until 2014, with values ranging from 0.6 to 0.8 for this period of seven years. We might assume that 10 years after the publication of land certificate, both land parcels have quite dense green vegetation in which can be assumed as mature oil palm, forest, or another mature plantations. Meanwhile, HGU A and HGU E, which were published in August and November 2003 respectively, had also a dynamic NDVI value. We are able to assume that there are plantations activities, those activities involve tree cut, deforestation or growth on both land parcels.

BFAST Monitor in Detecting Land Clearance

In this study, we present a land clearance detection approach by the BFAST monitor for the five HGU land parcels. We combined breakpoints and negative magnitudes to determine the land clearance. We set five different magnitude thresholds for the magnitude value. The importance to set the magnitude threshold in combination with the breakpoints is: 1) the breakpoints do sometimes have positives magnitudes or magnitude values near zero, which do not represent deforestation (DeVries et al., 2015), and 2) to get the best combination of breakpoints and magnitude thresholds to determine land clearance; pixels in which land cover will change from forest to bare soil.

We had different breakpoints in combination with different best thresholds when determining the land clearance for the five HGU land parcels. The best accuracies for HGU A, B, C, D, and E were achieved with breakpoints and a magnitude of -0.075, -0.070, -0.080, -0.060, and -0.075 respectively. From those five different best thresholds for each study area, in general the magnitude threshold of -0.075, as the mode of the thresholds, is the best threshold to be used for detecting land clearance in this particular study area. The best threshold value for determining the land clearance class in this study was different than the breakpoint and a magnitude threshold values determined by DeVries et al. (2015). In his study, the breakpoint and magnitude combination led to a value of -0.18 for determining discrete forest land clearance in southern Ethiopia. In general, the changes in our study areas typically had a higher magnitude value than the changes in Ethiopia. It means the decrease in NDVI values in our study areas were less than in Ethiopia. Although both Riau-Sumatra and Ethiopia have a humid tropical climate and have a humid tropical rain forest (Margono et al., 2012; Schmitt et al., 2010), the location of the study areas for this research is closer to the equator line, which might affect the vegetation characteristics, e.g. vegetation height, canopy crown, etc. Hence, the magnitude of land clearance might be different between our study and the study performed by DeVries et al. (2015).

Potential Errors and Limitations from BFAST Monitor Analysis

Land clearance detection is important in land parcel monitoring by NLA. The purpose is to check whether the land owner already uses the land as mentioned in the right entitlement or not. We have detected land clearance using the BFAST monitor algorithm by combining breakpoints and magnitude value. However, we still have potential errors and limitations in the present study, which will be discussed below.

The history and monitoring period are important for near real time monitoring (Verbesselt et al., 2012). However, it was a challenge to get dense temporal Landsat images for our time series because our five HGU land parcels are located in tropical forest area and cloud cover is a main issue for tropical areas (Hansen et al., 2009; Margono et al., 2012; Mitchard et al., 2011). Furthermore, gaps due to Landsat 7 ETM+ Scan line corrector (SLC-off) might be the source of data losses in our study areas. The during the rainy season, especially in January and December, the number of Landsat images is very low.

The data availability in the history and monitoring period might cause errors in our study. The history period is an important aspect for change detection in near real-time, which is important to define a stable reference model (DeVries et al., 2015; Verbesselt et al., 2012; Zhu and Woodcock, 2014). In the five years period, from 1st of January 2008 until the 31st of December 2012, the mean clear sky observations for the five selected study areas ranged from 14.78 to 25.32 out of the 81 available Landsat scenes. It means that the history data availability for the five study areas was quite low, in average; there were 55 to 66 loss observations during that period.

To determine our history period, we followed the paper of Verbesselt et al. (2012) which states that the length of the history period should be more than 2 years (>2years). However, during the data analysis in this study we found out that a history period of more than 2 years was insufficient to obtain a good result in land clearance detection. We observed two pixels on HGU A and found that both pixels had large no data gaps for the period between the middle of 2011 until the end of 2012, which was resulting in the false breakpoints. On the other hand, an example in which the fewer gaps in the history period resulted in true breakpoints is shown for some pixels. The observation data gaps might be caused by the high cloud cover and the fact that SLC was off. With the area of 23.318 ha, it was very challenging to get full observation due to the Landsat striping. Moreover, shows the cloud cover for observation and not available data per pixel. It is clear that in the period of 2008, 2010, 2011, and 2012, the cloud cover was relatively high, with values above 50% and some scenes were almost completely covered by clouds, 90% of cloud cover. Those images with a high amount of cloud cover were especially found at the beginning and the end of the year, due to the rain season. Our low temporal frequency of time series data for the history period is in line with what is stated in the paper of DeVries et al. (2015). This low history data leads to a problem when the time series method forms a stable model (DeVries et al., 2015) and might increase the commission errors (Zhu and Woodcock, 2014), which means that the algorithm detects changes at locations in which in reality there is no changes. To avoid these commission errors, we should use as many observations as possible (Zhu and Woodcock, 2014).

The data availability during our monitoring period might be the cause of our potential errors. The data during our monitoring period represents the new observed data that has been monitored for existence of disturbance. We used 26 Landsat images in our monitoring period, which was the period between the 1st of January 2013 and the 1st of July 2014. The mean clear sky observations for the five selected study areas ranged from 5.68 to 6.37 out of the 26 available Landsat scenes. It means our monitoring data availability for our study areas was quite low, in average; there were around 20 loss observations during this period. As the BFAST monitor works only for every available pixel in the time series, the low temporal data in the monitoring period might lead to high omission errors, which will result to the fact that the BFAST monitor does not detect the real changes.

The possible error in BFAST monitor used in this study was the determination of the forest mask at the beginning of the monitoring period. Our forest mask was only determined by supervised classification of SPOT 6 images for the year 2013. We did not refine our forest mask with a tree cover from Moderate Resolution Imaging Spectroradiometer Vegetation Continuous Fields (MODIS VCF) product as DeVries et al. (2015). The misclassification might occur especially when the HGU land parcels were already planted with oil palm. Hence, the omission error might increase in which the BFAST monitor would not detect the land clearance of misclassified pixels.

This study has a limitation in change detection accuracy in the temporal domain which is in line with Verbesselt et al. (2012). It means we did not assess the accuracy of the changes time detected by BFAST monitor because of a lack of information when the land clearance took place and limited amount of SPOT 6 images to validate the changes. We only used two SPOT 6 images which were acquired on 7 January 2013 and 17 June 2014. Hence, we can only observe the changes during that period and not in detailed detected breakpoints within this time interval. However, our results confirmed all changes took place in the period between January and June 2014, as our starting and end of the monitoring time, from which can be assessed that all the changes took place during the monitoring time.

One limitation of the BFAST monitor is that it does not directly provide information on the causes of forest disturbance (Verbesselt et al., 2012). Hence, we cannot make any analysis what is the source of the land clearance in the five HGU land parcels, whether it is because a proper land clearance or illegal land clearance, e.g., forest fire. Many farmers in Riau-Sumatra use fire in land clearance for oil palm plantation (Suyanto, et al., 2004) which is against the Government Regulation No. 11/2001 article 11 that prohibit people from engaging in forest fire activities.

Landsat Images to Support for Idle Land Controlling

Relatively lower values in the producer's, user's accuracy, and also largest confusions have been found in the classification of the land cover classes oil palm, forest, and grassland. The largest confusions were between oil palm and grassland, oil palm and forest, and also between forest and grassland. The spectral signatures of oil palm, forest, and grassland in some area are overlapping. Even in the layer 4 as the representation of band 5 (NIR) which is suitable for vegetation detection (Jia et al, 2014; USGS, 2013b), these three land covers are not well distinguished. Our result is in line with Jia et al. (2014) in which forest and grassland has the large confusion. This might occur, due to the fact that grasslands are often present close to the boundary of forest or in some small areas even in the middle of the forest (Jia et al., 2014). Moreover, in our case, grassland might be present near oil palm and oil palm was sometimes adjoined with forest. These conditions led to some misclassifications.

The accuracy assessment showed that the bare soil class had the highest accuracy among the other land covers. This is in accordance with the result of Jia et al. (2014), in which bare soil land cover class also had the highest accuracy among the vegetation classes.

The overall accuracy of this Landsat land cover classification was relative high with a percentage of 86.13% and a Kappa coefficient of 0.785 (a substantial agreement). Several comparable studies in which Landsat supervised maximum likelihood land cover classification has been performed resulted in high overall accuracies as well, like the studies of Yuan et al. (2005), Wu et al. (2006), and Jia et al. (2014), which have an overall accuracy of 93.98%, 89.32% and 90.4% respectively. Our approach is in line with Jia et al. (2014), Landsat 8 supervised maximum likelihood classification of surface reflectance bands 2 until 7. Therefore, we can conclude that Landsat 8 OLI data has a satisfactory performance in land cover classification.

Apparently, although Landsat 8 maximum likelihood supervised classification gave relative high total accuracies and Kappa coefficient, some classes had a low accuracy, which resulted in a large confusion.. Hence, it is quite difficult to assess the accuracy of those classes and distinguish between the different land covers. Bare soil seems to be the only land cover that might give a high accuracy, which can be used to detect idle land. The possible sources of errors in our classification are:

1. The determination of the reference classes for training and accuracy assessment. Our determination of reference classes was only based on visual interpretation of SPOT 6 images. We might have made some mistakes when determining the training areas and validating the classification result. Hence, it might cause a lower accuracy for some land cover classes.
2. The determination of the training areas. The training areas used for our classification were based on visual interpretation of our SPOT image. Although our method in training areas determination follows the approach used by Yuan et al. (2005), there is a possibility that our training areas were not evenly distributed. Hence, again it might cause a lower accuracy for some land cover classes.
3. The quality of Kampar land cover map as the validation data. According to the Geospatial Information Agency of the Republic of Indonesia, in general land cover maps are made based on aerial photographs using ground control points of the Control Network Center of Geodesy and Geodynamics for correction purpose. The level of detail of every single map is adjusted to the needs of the users in which every map scale has its own purposes and refers to Land Cover Classification System United Nation – Food and Agriculture Organization (LCCS-UNFAO) and ISO 19144-1 (BSN, 2010). Moreover, land cover maps with a scale of 1:50,000 have generalized land cover classes and are not very detailed (BSN, 2010). This lack in detail can be shown by the fact that the area of 1 cm^2 on the map corresponds with 500 x 500 m = 250,000 m^2 = 25 ha. HGU plot A and plot E have in total a size of around 25 ha, which is only 1 cm^2 on the map. However, we did not have any information about the quality of our land cover map as our ground truth data e.g., accuracy of the map. An example of how the classification technique or inventory technique used influences the classification of the landscape units is discussed in the paper of Hubert-Moy et al. (2001). In this paper a description is given of how the choice of a classification technique can significantly influence the results of the classification and what the effect is on the landscape units classified or identified within a study area. Therefore it is important that we keep into consideration that the identified land use classes in the Kampar land use map also has some

inaccuracies, which influence the classification result.

The Combination

Idle land controlling is one of the priority programs in the National Land Agency of the Republic of Indonesia which aims to make land right holders use their land according to the purpose of the entitlement. Since this program will abolish the legal relationship between the land owner and their land, every stage in idle controlling should be carried out based on the existing regulations. As mentioned in the explanation of idle land inventory stage (Fig. 3), the NLA officers should put attention to existing land cover and its land use history, for instance if officers discover bare soil or grassland as the existing land cover, they have to check whether it is already bare soil or grassland for a while or it is just there for a short period of time.

In this study, we combine the results of the BFAST monitor in detecting land clearance and Landsat supervised maximum likelihood in detecting existing land cover to support idle land controlling in Indonesia. Figure 21 illustrates an example of how we are able to obtain some findings which can be taken into consideration during indicated idle land inventory. It shows the combination of the BFAST monitor and Landsat 8 classification as idle land early detection (showed in red circle): (a) Land clearance detected by BFAST monitor (SPOT image in January 2013), (b) SPOT 6 image in June 2014, © Landsat surface reflectance bands in 5-4-3 composites in June 2014, (d) land cover map resulted from Landsat 8 classification. All these data sources are available for the NLA. In particular after the newest development that the National Institute of Aeronautics and Space provides high resolution satellite images, including SPOT images, to 9 departments in Indonesia including NLA from January 2015 onwards. However, the temporal resolution of SPOT images is lower than Landsat images which are freely downloadable.

If we look at Landsat 8 image in 5-4-3 composites (Fig. 21 ©), we cannot recognize what the land covers are in HGU E. With the infrared false color, we only might recognize some parts of the vegetation (red) and some parts of non vegetation (non red). After we classify the Landsat image, we get the land cover map (Fig. 21 (d)). From the confusion matrix in Table 14, we can conclude that bare soil, as early indication of idle land, had the highest accuracy compared to other land cover classes. Red circle in Fig. 21 (d) shows that there is bare soil as the existing land cover. However, we cannot just make final conclusion based on this land cover, we still should look at what might happen in the past. Hence, we look at our BFAST monitor result to check what might happen in the past. Red circle in Fig. 21 (a) shows that for the period January 2013 and June 2014, there is a land clearance/activity on HGU E which means the land owner uses the land. Based on the BFAST monitor result, this area is eight pixels which equals to 0.72 ha.

Next, we look at grassland, which is indicated with the black arrow (Fig. 21 (d)). The existence of grassland in the existing land cover is also sometimes indicated as idle land. During 2013 until 2014, we do not have any changes, because this area is not considered as forest class. Therefore the BFAST monitor algorithm does not take into account this area in the calculation. Hence, we look at our annual median NDVI to see what might happen in this area. Fig. 25 in Appendix I shows there is a decrease in NDVI values during 2012 and 2013, which might lead to the conclusion that there is an activity in that area (black arrow). These observations and findings would help NLA to decide whether HGU E will be targeted for idle controlling or not.

Conclusions

In this section, an overview of conclusions about the main findings related to idle land early detection is provided. It also addresses the results for each research questions formulated at the beginning of this study and concludes about the feasibility of BFAST monitor as a method for idle land early detection. Furthermore, a conclusion will be made about suitability and accuracy of Landsat maximum likelihood supervised classification as an approach for idle land early detection.

For the National Land Agency of Indonesia, the land use history and the existing land cover plays an important role in the idle land controlling, especially for the indicated idle land inventory. In our study, it was shown that the annual NDVI time series and the BFAST monitor were able to show the land use history of our five selected HGU land parcels. The annual median NDVI was able to show the plantation pattern and from its value, we could derive the possible activities on the HGU land parcels. Furthermore, land clearance practices were evidenced from the Landsat time series using the BFAST monitor by combining the breakpoints and different negative magnitude threshold values. Overall, the magnitude threshold between -0.060 and -0.080 was the best threshold in detecting land clearance for each study area. However, in general the magnitude threshold of -0.075, as the mode of the thresholds, was the best threshold to be used in land clearance detection for this particular study area.

For assessing existing land cover on the HGU land parcels, Landsat 8 supervised maximum likelihood classification of surface reflectance bands 2 until 7 has been used. This approach had a good performance in land cover classification, with an overall accuracy of 86.13% and a Kappa coefficient of 0.78, which shows a substantial agreement. We concluded that detecting bare soil, as one of the indications of idle land, is more accurate than vegetation i.e. oil palm, forest, and grassland.

A major aspect which limited the usability of our methodology was the high cloud cover in tropical areas. This situation led to a low data availability, which results in high commission and omission errors. By bringing together all our results in this study, it gives many opportunities for NLA to have an idle land early detection method to decide whether a land parcel will be targeted in the idle land controlling or not. A continuously development in the idle land controlling stages is necessary for NLA to gain a good land management in Indonesia.

Evaluasi dan Perancangan Ulang Strategi Intervensi Pemerintah Urban untuk Mendapatkan Kembali Hak Lahan dari Penghuni Liar; Studi Kasus Di Kathmandu, Nepal

Evaluation and Redesign of Urban Governance Intervention Strategies to Attain Land Tenure Security for Squatters: A Case Study in Kathmandu, Nepal

Nama	: Mas Bambang Agus Wijaya
NIP	: 198008302006041005
Instansi	: BPN
Tahun Intake	: 2012
Tingkat Beasiswa	: Master Overseas
Program Studi	: Master of Science Degree in Course for Land Administration
Negara Studi	: Belanda
Universitas	: University of Twente

ABSTRAK

Pertumbuhan penduduk yang tinggi di Kathmandu, ibu kota Nepal telah menghasilkan tingkat permintaan yang tinggi untuk perumahan. Situasi ini semakin menciptakan ketidakseimbangan antara kebutuhan perumahan dan persediaan perumahan dan menyebabkan pertumbuhan permukiman liar ditambah dengan tidak adanya jaminan kepemilikan lahan bagi penghuni liar. Oleh karena itu, tantangan penting bagi pembuat kebijakan untuk menangani masalah keamanan kepemilikan lahan bagi para penghuni liar.

Penelitian ini bertujuan untuk mengevaluasi dan mendesain ulang strategi intervensi tata kelola kota untuk mencapai keamanan kepemilikan lahan bagi penghuni liar. Untuk tujuan penelitian ini, pilihan wilayah Bansighat di Kathmandu diinformasikan oleh tingkat pertumbuhan penduduk liar yang cepat selama bertahun-tahun. Data untuk penelitian dikumpulkan dengan mewawancarai pemangku kepentingan utama dalam strategi intervensi tata kelola kota untuk mendapatkan kepemilikan lahan yang terjamin, pengumpulan foto udara dan citra satelit Bansighat antara tahun 1992 dan 2013.

Hasil dari tanggapan wawancara menunjukkan situasi memburuknya pemukiman liar di Bansighat dari sudut pandang penghuni liar dan pemerintah. Selain itu, citra yang menunjukkan tingkat pertumbuhan dan pola pemukiman liar antara tahun 1992 dan 2013 divisualisasikan dan didigitasi. Selanjutnya, analisis naratif wawancara mengarah pada evaluasi perbedaan antara strategi intervensi pemerintah yang ada dan prioritas para penghuni liar dari indikator strategi intervensi ini. Analisis "SWOT" diimplementasikan untuk menyelaraskan strategi intervensi yang ada dengan prioritas penghuni liar untuk indikator strategi ini. Hasil analisis ini adalah pengembangan 12 strategi intervensi baru yang dapat dianggap sebagai inti dari penelitian ini.

Untuk menyimpulkan, penelitian ini telah berhasil mengevaluasi dan mendesain ulang strategi intervensi tata kelola kota yang ada dengan tujuan untuk memungkinkan penghuni liar di daerah Bansighat di Kathmandu untuk mengakses kepemilikan lahan yang aman. Rekomendasi yang dikemukakan dalam penelitian ini meliputi kebutuhan akan studi terkait yang diarahkan untuk memvalidasi hasil penelitian ini dan menghasilkan temuan baru yang mampu mendukung program pengamanan kepemilikan lahan untuk penghuni liar. Akhirnya, modifikasi lebih lanjut dari analisis "SWOT" direkomendasikan untuk studi serupa tentang keamanan kepemilikan lahan untuk penghuni liar, terutama bila kebutuhan untuk menyeimbangkan kebijakan pemerintah dengan harapan penghuni liar menjadi hal yang penting.

Kata kunci: Tata kelola kota, strategi Intervensi, keamanan kepemilikan lahan, penghuni liar, Nepal

ABSTRACT

High population growth in Kathmandu, the capital of Nepal has generated a high level of demand for housing. This situation further creates an imbalance between housing need and housing supply and leads to the growth of squatter settlements coupled with the absence of land tenure security for the squatters. Therefore, an important challenge is for policy makers to address the issues of land tenure security for the squatters.

This research aims to evaluate and redesign urban governance intervention strategies to attain land tenure security for squatters. For the purpose of this research, the choice of Bansighat area in Kathmandu was informed by the rapid growth rate of squatter settlements over the years. Data for the research was collected by interviewing major stakeholders in urban governance intervention strategies for secure land tenure, collection of aerial photograph and satellite images of the Bansighat between 1992 and 2013.

Results from interview responses indicate the deteriorating situation of squatter settlement in Bansighat from the viewpoints of squatters and government. In addition, image indicating the growth rate and pattern of squatter settlement between 1992 and 2013 were visualized and digitized. Furthermore, narrative analysis of interviews led to an evaluation of divergence between existing government intervention strategies and squatters' priority of the indicators of these intervention strategies. "SWOT" analysis was implemented towards harmonizing the existing intervention strategies with priority of squatters for the indicators of these strategies. Outcome of this analysis was the development of 12 new intervention strategies that can be regarded as the core of this research.

To conclude, this research has successfully evaluated and redesigned the existing urban governance intervention strategies for the purpose of enabling squatters in Bansighat area of Kathmandu to access secure land tenure. Recommendations put forward in this research include the need for a related study geared towards validating the results of this research and generate new findings capable of supporting programmes for land tenure security for squatters. Finally, further modification of the "SWOT" analysis is recommended for similar studies of land tenure security for squatters especially when the need to balance government policy with expectations of squatters becomes crucial.

Keywords: Urban governance, Intervention strategies, Land tenure security, Squatters, Nepal

Urban growth in many developing countries is usually associated with the emergence of squatter settlements (Garba & Al-Mubaiyedh, 1999). The cause of this trend is that rural people tend to migrate to urban area attracted by better infrastructure and job opportunities. With respect to Kathmandu, the capital of Nepal, high population growth generates a high level of demand for housing such that there is an imbalance between housing need and housing supply which leads to the growth of squatter settlements.

Given the relative demand inelasticity for land and the limited availability of formal settlements, the prices of land and housing tend to be escalated (de Souza, 1998). With little financial resources, skills or access to formal settlements, poor people illegally occupy land to build low quality shelters (Srinivas, 1999), irrespective of who owns the land and notwithstanding the environmental hazards arising from the development of shelters along flood plains or riverbanks (Rashid, 2009; Shrestha, 2013). Furthermore, there are semi-permanent houses without any facility such as tube-well, electricity and neighbourhood infrastructure among which include schools and health care centres (Rashid, 2009).

Squatter settlements are predominantly characterized by urban poverty, although not all squatters are actually poor (Roy, 2005). A challenge for policy makers in most developing countries is how to address issues of shelter and security of tenure for the urban poor (de Souza, 1998). Interventions by non- governmental organizations (NGOs) towards improving the livelihood of squatters had been directed towards certain poverty reduction programs and provision of facilities such as primary school, drinking water, public toilet, and provided electricity supply (Karki, 2004). Irrespective of these NGO interventions toward provision of social amenities, the land tenure problem arising from illegal occupation of land for squatter settlement development has lingered on to date because NGOs alone do not have authority to confer secure land rights on squatters.

The emergence of squatter settlements in Kathmandu, Nepal has dynamic implications for the squatters, the NGOs, and the government. NGOs have tried to help the squatters to obtain land rights on their land by advocating a land reform which addresses the needs of squatters (Babu, 2008); but the reach of these NGOs is only limited to advocacy as they may not really influence intervention strategies by the government towards granting tenure security to these squatters. There are possibly three intervention options which the government may use to handle this issue. The first option is for the government to evict all squatters without provision of alternative land or shelter (GTZ, 1998; UN-Habitat, 2004). The second option is for the government to design and negotiate relocation of all squatters to alternative site where they will be given secure tenure rights and minimum rehabilitation incentives (UN-Habitat, 2004, 2008). The third option is for the government to relocate squatters residing near vulnerable sites to a more safe location where they can be given secure tenure rights, while giving incentives of more secure tenure to the remaining squatters living far away from such vulnerable areas (Rashid, 2009). Among these options, it is not known which of them is suitable towards handling the situation in Kathmandu.

This research evaluates and identifies the necessary requirements for urban governance intervention strategies, with the specific aim of granting land tenure security for squatters. While the most suitable intervention strategy for granting tenure security to squatters in Kathmandu is not currently known, this research is undertaken within the perspective of urban governance research, aiming at the perceptions of stakeholders for a suitable intervention strategy.

According to van Gelder (2010), tenure security is difficult to measure. The only acceptable approach of measurement is relying on the perception of squatters, and assessing the strength of their relationship with the land under consideration. Furthermore, the provision of slum clearances and other forms of forced evictions are intervention strategies which tend to create problems which go beyond the capacity of the government to resolve (Garba & Al-Mubaiyedh, 1999), such problems include destruction of property, loss of assets, breakdown of social relations, and loss of access to social infrastructure and amenities (Parsa et al., 2011).

As a result of these negative impacts, a number of studies have been conducted towards developing innovative land tenure systems to afford squatters the possibility of having more secure land rights (Minnery et al., 2013; Parsa et al., 2011; Zevenbergen et al., 2013). The caution with these intervention strategies is that their requirements vary from country to country and as such demands country specific applications (Zevenbergen et al., 2013). It is in view of this development that a unique form of intervention strategy is required for Kathmandu. In order to come up with a feasible strategy for Kathmandu, it is important that acceptability of salient features of successful strategies across the globe should be assessed within the context of squatter settlement.

Although it is known that Government exercises governance intervention strategy to provide land tenure security to its citizens, there are situations whereby squatter settlements development creates a problem of insecure land tenure for squatters as well as complex land management problems for the government. However, it is not known which intervention strategy is feasible towards providing squatters with more secure tenure rights. In addition, it is not known how a chosen intervention strategy contributes to land tenure security for the squatters.

The main objective of this research is to determine urban governance intervention strategy for contributing towards improved land tenure security for squatters in Kathmandu, Nepal.

The methodologies applied in this research are case study and design research. Yin (2003) stated that case study research is the study of which addresses complicated and real-life situations especially when a research problem is moderately structured. The case study methodology is implemented because the context of squatter settlements management cannot be clearly distinct from the observable interactions between various stakeholders within that context. Data collected during fieldwork phase were presented in quantitative approach such the presentation of distribution tables and qualitative approach by weighting the respondent's preference in purpose to find the rank of preference.

Design research is a combination of theory and practice for the purpose of improving an existing invention or situation (Laurel, 2003). This methodology usually leads to an innovations or development of intervention which are better than the existing versions. In order to develop an intervention strategy for tenure security, this research will use the result of data presentation from the case study method above.

Squater Settlement in Bansighat Neighbourhood

For the beginning, there is an interesting finding from the survey results on long time period of land occupancy. According to the map of Bansighat squatter settlement in the year 1992, it was only small number of buildings existed in the area. Surprisingly, 34 of 47 respondents claimed that they have live in the Bansighat area for more than 20 years. The un-accordance answer from the respondents to the fact might be because they want a recognition that they have lived for long time in that area. Another reason is the lack of control in the implementation of the survey on the field. The image of Bansighat area in year 1992 was collected after the interview with the squatters, so it did not used as a guide in the formulation of questionnaire on the "long-time occupancy" question.

In addition, according to the map of Bansighat area in year 2001, there are many building that can be identified in Bansighat squatter settlements. Therefore, with the respect of comparing the answer from respondents with the map of Bansighat area in year 2001, at least some squatters have been live in that area more than 10 years or even more than 15 years.

In the socio-economic standpoint, analysis derived from the results of the interview with the squatters indicates that less educational background and financial followed by the high value of the property such as house purchasing as well as renting the house in Kathmandu finally urged the squatters choose to live in squatter settlements such as on the land near the Baghmati River. With the limited-capability, they settled and become a community in Bansighat area.

From the legal point of view, the result of interview indicates there were some illegal properties transactions on the land belong to the government even though the squatters did not mention the details of the transaction. It indicates that Bansighat is a suitable area for the squatters to settle and they ignore the legal aspects on the property transactions. Furthermore, the illegal transaction has created the emergence of some land disputes experienced by squatters in Bansighat. However, additional information obtained from respondents who had experienced on a land dispute with a neighbour indicates that the land dispute between squatters does not mean anything because they realize that they live on the land belongs to the government.

On the safety life viewpoint, even Bansighat is located near the river, but more squatters feel safe during stay in their house rather than squatters who worrying due to the flood experience in the past. Due to the need of housing, the safety aspect has been ignored by the squatters.

Existing Intervention Strategies for Land Tenure Sacurity

Firstly, the analysis indicates that there are four relevant intervention strategies to attain land tenure security for squatter are possible to be implemented in Kathmandu.

Implementation of resettlement plan which will encourage squatters to move to a new location prepared for them while discouraging most of them from returning and occupying land near Baghmati River.

Information gathered from the government organizations, non-governmental organization and academic respondents describe that there was a failure experiences in the relocation program (in other area in Kathmandu). This is because un-prepared of the relocation program's plan. Therefore, the government actions that could be carried forward such as:

1. Set up a new area that is suitable for settlement;
2. Set up of public infrastructure in new areas such as road access, electricity and clean water;
3. Socialize the relocation plan to the squatters; and
4. Socialize of law enforcement and supervision in order to avoid re-acquisition of land by squatters.

Relocation of squatters living in areas those are vulnerable to natural disasters (e.g. floods) to safer place.

Perceptions by the government's respondents indicate that the land around the river is not appropriate to be used as settlement. The most feared dangers of floods occur when water flowing in the river exceeds the capabilities of the river. The flood can damage property which is located in surrounding the watershed. Furthermore, as the structure of the building owned by squatters along the river usually is not strong, then the impact is particularly vulnerable when the flood comes. The losses will be worst if it was not just a building damaged by flooding, but the possibility of lives could be lost because of the floods could come at any time. For that, the intervention of the government that might be fit is the relocation of squatters who live in disaster-prone areas to safer places.

Build the low-cost apartment for the squatter with the purpose of optimization on limited availability land in Kathmandu.

Statements by the government's respondents indicate that the availability of land in Kathmandu is limit coupled by the high price. This condition causes the local government of Kathmandu may not provide lands for the all residents of Kathmandu including squatters. Therefore, to overcome the situation, the government should maximize the availability of land in Kathmandu through the development of low cost apartments. The purpose is to give the opportunity to the low-economic level residents and the squatters to live more feasible in the apartment. The advantage of this program is a lot of household can be accommodated in apartments and easy support on providing facilities such as electricity and water for each household. In addition, information gathered from the government's respondents tells that the government has a low-cost Kathmandu apartment's program that can accommodate about 250 households.

Implement integrated land redevelopment activities comprising slum clearance, road construction, and protection of ecosystems around Baghmati River through the construction of a natural park.

This relevant intervention strategy indicates that implementation of relocation's program should be accompanied by the implementation of the rehabilitation of ex-squatter settlement. The land should be clean of buildings and then changes the land use immediately. Information obtained from the government's respondents illustrates that the land use in Bansighat squatter settlement will be changed into a natural park and there will be road access along the river. The land rehabilitation hopefully will avoid the next land encroachment by squatters.

The second discussion is about squatters' prioritizing on indicators of intervention strategies (Table 5). Ranks first to fifth include participatory urban planning, recognition of settlement, grant of land use rights, grant of secure tenure on condition of long time occupancy and attention to input from the public concerning urban planning indicate that the squatters want to be recognized by the government as same as other citizens in the involvement of government intervention strategies' implementation followed by the hope on the granting of land tenure rights. While rank sixth and seventh include settlement rehabilitation for improved land tenure security and integrated relocation and compensation policy indicate that the squatter only see a less chance of better infrastructures' provision by the government, but they do not want to be relocated to other area.

The third discussion is focusing on the match of existing governance intervention strategies with the rank of intervention strategies' indicator by the squatters as presented in Table 6. Rank first, fifth and seventh in Table 5 match with two existing intervention strategies. Rank third follows the rank first and seventh in other existing intervention strategy.

Rank second not be a feasible indicator for the implementation of the intervention strategies given the intention of government to control the ecological problems arising from the squatter settlement development along Baghmati River. Furthermore, since the government is not prepared to allow squatters to remain within Bansighat area, inference can be drawn that rank fourth does not match any existing intervention strategy from the government. In other words, no existing governance intervention strategy might be channelled into granting of secure tenure for squatters on condition of long term occupancy because of the vulnerability of that area to ecological disasters like flooding let alone the attendant cost of relief which might be borne by government in the event of occurrence of these disasters. This reason also applies to the rank sixth of indicator of settlement rehabilitation for improved land tenure security.

In addition, the development of feasible urban governance intervention strategies to attain secure land tenure for squatters should strike a balance between squatters' preference of governance indicators and existing intervention strategies put in place by the government to bring about tenure security for these squatters while ensuring their safety.

Development of Intervention Strategy

Following the use of SWOT analysis introduced in section 5.3, a total of 12 feasible intervention strategies were developed using the existing strategies as a foundation. These strategies have been examined in systematic order of implementation:

1. Improve efficiency of land governance institutions through collaboration among stakeholders. As observed from the satellite, the high growth of squatter settlement over the years (1992 - 2001 and 2001 - 2013) in Bansighat area would have been averted if governance institutions and stakeholder had been efficient in their operations and collaborative efforts. Therefore, an intervention strategy which should serve as a primer to other strategies is the need to improve efficiency of land governance institutions in the Kathmandu through collaboration among stakeholder comprising civil servants and government organizations, squatters, and civil society groups. The essence of this intervention strategy is help build trust among the stakeholder because without this trust, no meaningful implementation of these strategies.
2. Persuasive relocation of squatters to alternatively safer sites where they are guaranteed secure land tenure. The existing situation whereby squatters live on the land that is near to river and prone to disasters like floods poses a threat to

their social well-being. Therefore, an intervention strategy aimed at convincing squatters to relocate to safer sites where they are guaranteed secure land tenure is important. The role of government is to apply persuasive approaches such as mass media campaigns, religious organizations, and cooperatives towards promoting relocation of squatters to safer sites where they will be given secure land rights.

3. Issue certificates of land use rights in alternative sites as a motivation for squatters to be relocated. Existing intervention strategies do not support the conferment of secure land titles to squatters in Bansighat area. In addition to persuading squatter to relocate from Bansighat, government can further motivate them to relocate by granting them certificate of land use rights in an alternative site. This strategy might be better appreciated by squatters if implemented in conjunction with the provision of better infrastructural facilities in resettlement sites as examined in the next paragraph.
4. Provision of better infrastructural facilities in resettlement sites. It is the policy of government that squatters in Bansighat should be relocated to alternative site prepared for them. However, the desire of squatters to relocate depends on the availability of better infrastructural facilities such as domestic water supply, power supply, roads, schools, hospitals, and a local market in resettlement sites compared to facilities in existing squatter settlement. In other words, squatters might be willing to relocate if they are assured of secure land use rights (strategy c) and access to better infrastructural facilitates in alternative site.
5. Offer housing development subsidy in alternative sites as a motivation for squatters to be relocated. It is recalled from Table 4 in section 4.3 that government does not tolerate the expansion of squatter settlement in Bansighat; hence, informal housing developments in the squatter site are implemented at a cost for the squatters who are uncertain about future demolitions. Therefore, an intervention strategy is directed towards providing housing subsidy to motivate squatters to be relocated to alternative sites and avert the risk of informal housing development in Bansighat and its likely future demolition costs.
6. Construction of low cost housing or apartments in resettlement sites as a viable alternative to squatter settlement rehabilitation. Although squatters in Bansighat prefer settlement rehabilitation programme, existing urban governance strategies cannot intervene to permit such preference. However, The SWOT strategy indicates that squatters' preference for settlement rehabilitation in Bansighat can be sustainable if translated into construction of low cost housing or apartments in resettlement sites considering limited availability of land in Kathmandu. Strategy 3 may be implemented alongside or in place of strategy b.
7. Joint participation of stakeholders towards creating jobs and other economic opportunities for resettled squatters. SWOT analysis further indicates that for the

new intervention strategies to succeed, stakeholder participation is required in order to create jobs and other economic opportunities for resettled squatters before their relocation. Therefore, these squatter shall be willing to relocate to alternative sites if they are assured of continuity of their livelihood or better livelihood opportunities compared to what they currently have.

8. Participatory decisions towards squatter settlements rehabilitation for environmental protection. It is recalled from section 4.3 that the government prefers all squatters to be relocated to alternative sites in order to pave way for the construction of natural parks and roads. The SWOT analysis proposes intervention strategy which targets the rehabilitation of Bansighat area for environmental conservation uses that are more economically viable besides natural parks and roads as proposed in the existing intervention strategy. It is envisaged that stakeholder participation and commitment is required for the conversion of Bansighat area into environmental protection site in order to avert any further encroachment because squatters at this stage should have been attracted by strategies a to g as motivation to relocate to an alternative site.
9. Timely restriction of access to existing squatter settlement following immediate relocation of all squatters. It is timely for the government to secure existing squatter settlement for environmental protection purposes immediately a deal is reached with stakeholders that squatters shall be relocated. In other words, timely restriction of access to Bansighat area after squatters might have relocated will help send a clear message to all stakeholders that the area is now under government control such that no squatter will be allowed to come back to that area again because an alternative site and necessary intervention strategies of secure tenure rights have been provided for them.
10. Enforcement of land use regulations to avoid land encroachment. Related to strategies a, strategy h, and strategy i is strategy j which suggests that government and its relevant institutions in Nepal should enforce land use regulations to avoid land encroachment in Bansighat area after it must have been secured by the state for environmental protection purposes. Through this intervention strategy, further growth of squatter settlement and its associated negative impacts such as urban congestion, pollution and poor hygiene can be kept under control.
11. Replace existing squatter settlement with natural parks and environmental protection infrastructures. This existing intervention strategy is threatened by squatters' request for settlement development within ecologically hazardous land. Hence, strategy k seeks to balance these diverging interests by suggesting the replacement of Bansighat area with natural parks and infrastructure that will foster environmental protection in line with strategy 8. Replacement of Bansighat area

with these environmental protection infrastructures can be feasible strategy after squatters have relocated successfully.

12. Enforce land use regulations and restrictions against further growth of squatter settlement. Given the opportunity created by squatters' willingness to participate in urban planning, another intervention strategy is the enforcement of land use regulations and restrictions especially in the resettlement site in order to avoid emergence of squatter settlements. Specifically, enforcement of land use regulations and restrictions might accompany land use rights granted to beneficiaries of the relocation programme as a means of averting growth of another squatter settlement.

Conclusions

With the aim to complete this research, there are three sub-objectives that have to be achieved. Sub- objective 1: "To examine the growth of squatter settlement" has been achieved by answering the following research questions:

- "How did the squatters occupy land in Kathmandu?"
  This question has been answered in Chapter 3 described by the findings that most of squatters live in that area by occupying the available land found by their self, purchase from another person illegally and other ways such as marriage or given by parents. Reasons that followed the way of occupancy include the high price for house renting in Kathmandu, find the job and had no choice have urged those squatters to live in squatter settlement.
- "How long have these squatters been there?"
  The answer of this question is described by the statement from 34 of 47 respondents who claimed that they have occupied the land for more than 20 years, 6 respondents claimed between "15 – 20" years, 4 respondents claimed between "10 – 15" years and 3 respondents claimed that they have occupied the land between "5 – 10" years.
- "What is the extent of squatter settlement growth over the years?"
  The illustration of the Bansighat squatter settlement's growth has been presented in Chapter 3. Result of image processing has identified that small amount of buildings covered this area. Then, map of year 2001 has illustrated a lot of buildings appeared in this area. Furthermore, the area was transformed into a wider squatter settlement in year 2013. In addition, there is an interesting finding when comparing between question (1.b) and (1.c). With regard to the statements from squatters compared to the emergence of buildings in Bansighat area, it can be concluded that some squatters have been stayed in Bansighat area at least more than 10 years.

Partisipasi Masyarakat dalam Program Konsolidasi Tanah di Indonesia Studi Kasus di Desa Umbulharjo dan Kepuharjo, Kabupaten Cangkringan, Kabupaten Sleman, Provinsi Diy

Public Participation in Land Consolidation Program in Indonesia Case Study in Umbulharjo and Kepuharjo Village, Cangkringan District, Sleman Regency, Province of Yogyakarta

Nama	: Nina Windialika
NIP	: 198505102009032009
Instansi	: BPN
Tahun Intake	: 2013
Tingkat Beasiswa	: Master Overseas
Program Studi	: Master of Science in Land Management and Land Tenure
Negara Studi	: Jerman
Universitas	: Technische Universitat Munchen

ABSTRAK

Konsolidasi tanah di Indonesia telah dilakukan di 900 lokasi di 30 dari 34 provinsi dari tahun 1982-2012. Ironisnya, banyak orang masih belum tahu apa itu konsolidasi lahan. Apalagi keterlibatan partisipasi masyarakat dalam konsolidasi tanah merupakan kewajiban. Namun demikian, beberapa laporan menunjukkan bahwa tingkat partisipasi masyarakat masih rendah. Tujuan utama dari penelitian ini adalah untuk mengevaluasi proses konsolidasi lahan dan untuk mengidentifikasi cakupan partisipasi masyarakat. Kemampuan untuk mengenali masalah konsolidasi lahan dan keterlibatan akan membantu institusi terkait memperbaiki layanan dan meningkatkan keterlibatan peserta publik.

Penelitian ini dilakukan di kecamatan Umbulharjo dan Kepuharjo dan penelitian lapangan dilakukan pada bulan September-Oktober 2014. Penelitian kualitatif telah dilakukan, namun metode kuantitatif digunakan untuk mendukung penjelasan tersebut. Untuk mendapatkan analisis yang komprehensif, baik data sekunder maupun data primer dikumpulkan.

Hasilnya menunjukkan bahwa proses konsolidasi lahan di wilayah studi belum sepenuhnya mengikuti prosedur. Selain itu, penelitian tersebut telah mengetahui bahwa ada informasi publik yang tidak memadai, tidak ada sistem konkrit untuk partisipasi publik dan kurangnya kapasitas kelembagaan untuk melakukan partisipasi publik. Oleh karena itu, penulis merekomendasikan penyediaan ahli partisipasi masyarakat, pengembangan kapasitas untuk pejabat yang terlibat dalam konsolidasi lahan dan partisipasi publik, pembentukan komite penasihat atau dewan, kesadaran masyarakat untuk memberdayakan masyarakat mengenai partisipasi masyarakat, latar belakang peserta publik dan pengakuan nilai dan definisi bagaimana partisipan terlibat.

Kata kunci: konsolidasi lahan, partisipasi masyarakat, dusun umbulharharjo dan kepuharjo, Indonesia

ABSTRACT

Land consolidation in Indonesia has been undertaken at 900 locations in 30 out of 34 provinces from 1982-2012. Ironically, many people still do not know what land consolidation is. Moreover, the involvement of public participation in land consolidation is an obligation. Nevertheless, some reports show that the level of public participation is still low. The main objectives of this research are to evaluate land consolidation process and to identify the scope of public participation. The ability to recognize the land consolidation problems and the involvement will help the related institutions improve the service and increase the involvement of public participants.

This study was conducted in Umbulharjo and Kepuharjo sub-villages and the field research was conducted in September-October 2014. Qualitative research has been selected, but quantitative method is used to support the explanation. In order to have comprehensive analysis, both secondary and primary data are collected.

The results indicate that the land consolidation process in the study area has not fully followed the procedures. In addition, the research has recognized that there is inadequate public information, no concrete system for public participation and lack of institutional capacity conducting the public participation. Therefore, the author recommends the provision of public participation's expert, capacity building for the officials involved in land consolidation and public participation, the formation of advisory committee or councils, public awareness to empower communities regarding public participation, public participants' backgrounds and values recognition and the definition of how the participants involved.

Keywords: land consolidation, public participation, umbulharharjo and kepuharjo sub-village, Indonesia

Traditionally, land consolidation has always been regarded as a primary land management approach for rural development. The reason is because early concepts of rural development were virtually the same as agricultural development, due to the predominant role of agriculture in rural areas at that time. Consequently, the primary aim of land consolidation focused on the creation of competitive agricultural production arrangements, by enabling farmers to have farms with fewer parcels, to have larger and better shaped fields and to expand the size of their holdings.

Over time, land consolidation is not only seen as a tool for increasing agricultural production and productivity, but also environmental protection such natural ecosystems, soil, water and landscape protection (LGL, 2009). Also, land consolidation has functions to resolve of conflicts concerning the ownership and boundaries and to get optimum results of land management policies and applications.

Moreover, land consolidation mediates between different interests. To keep traditions and cultural values of rural structure alive, provides infrastructure development, renewal of cadastral records and public register, improves livelihood in villages and creating new job opportunities in order to prevent immigration from rural to urban are several aims from diverse stakeholders.

Thus, it is obvious that goals of land consolidation vary mainly depends on the needs and advancement of a country (Konečná, Podhrázska, & Toman, 2012). Regarding the objectives of land consolidation, different goal setters may have different emphases considering the same operational objective.

According to Van Dijk (2003 quoted in Demetriou, 2014) the first conception of land consolidation began in 1343, in the region of Bavaria in Germany, when monks spontaneously exchanged parcels in the village of Oberalteich. The idea was adopted a century later (1435) in the Netherlands, when members of the Agnieten monastery in the city of Zwolle consolidated the land parcels into a 50 ha area. Some years later, in 1450, the concept emerged in Italy. Afterwards, the concept spread to other European countries: in Denmark (1650); in France (1702); in Switzerland (1808); in Spain (1850); in Norway (1859). Although the concept of land consolidation began early in the fourteenth century, legislation was only adopted some centuries later.

In Indonesia, land consolidation commenced in the early 1980s with its pilot project occurred in Renon, Bali. The project, which encompassed 77.25 Ha in 589 parcels was successful in the economic point of view, although it took several years to be accomplished compared nowadays. Archer (1992) states that Indonesia was the first Southeast Asian country to adopt land consolidation technique. Getting influence by Japan, many land consolidation projects in Indonesia take place in urban areas. Japan, Taiwan, Germany and more countries use the term urban land readjustment to show the land rearrangement in urban areas. Indonesia experienced the term land readjustment in the first ten years before the regulation about land consolidation came up in 1991. Up to now, land consolidation is a term used to show both land rearrangement in urban and rural areas.

Based on Regulation of the Head of National Land Agency No. 4 of the year 1991, land consolidation is land policy associated with the rearrangement of land tenure and land use as well as the effort of supplying land in accordance with the development and to conserve the natural resources by involving active participation of the community.

The goal of land consolidation in Indonesia is the existence of land tenure and land use arrangement in order and regularly managed. In some locations land consolidation means rearrangement land in order to have better shape and better accessibility, while some others, land consolidation imply provision of new housing site, and solving land conflicts as well. It is because the range of priority areas needed to be consolidated is quite wide, from proposed land, built up area, up to former disaster area and conflict area.

From 1982 to 2012, land consolidation in Indonesia has been undertaken at 900 locations in 30 out of 34 provinces, covering a total area of 168,172.242 hectares, involving 212,242 landowners, and replotting 232,231 parcels. Ironically, many people still do not know what land consolidation is although it has been carried out since long time ago. In addition, practicing a lot of land consolidation projects all over the nations does not mean Indonesia has successfully managed them. A lot of issues come up in different ways.

Among many policies concerning the arrangement of land tenure and land use, land consolidation in Indonesia is a method of development that combine the legal aspect of land tenure and physical aspect of land use based on spatial plan, involving active participation of landowners. Therefore, land consolidation is essentially the application of equity and justice principles through landowner participation in land development, while at the same time practicing land tenure and land use management.

There have been numerous studies asserting the benefits of involving citizens and stakeholders in decision making at various levels in government and regulation. Public participation in societal decision-making is becoming more and more common. According to Louwsma, Van Beek, & Hoeve (2014) public participation in land consolidation may take place in various ways, depending on legislation, the local context and followed procedure. Oltheten (1995) states in his synthesis report that the range of participation from 'we want them to participate in what we do' to 'we want support them in the achievement of their goals'.

The philosophy of land consolidation in Indonesia is 'from people, by the people, and for people' which means putting public participations above all and having the opportunity to decide what they need and want and the government try to support it. In fact, running legal & physical aspect and expecting active participation do not always get along. Some findings show that many participants revoke their participation. A number of reasons such as the feeling of being disadvantaged by taking part of this project and unwillingness to donate their lands emerged. These matters might come from the limited roles of the public participations. Probably, the model of public participation is on passive way.

A research conducted by Cahyaningsih (2003, p. 4) reveals that the level of public participation from preparation to implementation is below expectation. This poor level of public participation is reflected in low percentage of Land Donation For Development (LDFD). LDFD is the essential element that enacts land consolidation as participative land policy. Nonetheless, LDFD itself is not the only factors that cause low level of public participation. Based on the explanation above, the problem statement is "A lot of public participants have less knowledge as well as their poor roles in Land Consolidation program".

In terms of problem statement that have stated above, the goal that have to be achieved in this research are:

- To evaluate present land consolidation processes in the case study area;
- To identify the scope of public participation

The primary reasons behind the limited public participation are inadequate public information, no concrete system for public participation and lack of institutional capacity conducting public participation. For effective and practical implementation, provision of sufficient information about land consolidation, a legal framework for public participation, and institutional capacity building are needed.

Land Consolidation in Indonesia

Land consolidation in Indonesia, which begun in the early 1980s, is a way to restructure land tenure and the provision of infrastructures. When it was first applied in Renon, Denpasar city, the province of Bali, it was quite successful due to increasing land values and therefore, land owners from the neighbor area asked to do the same way. However, up to 1991, there is no regulation or policy that guides the process of it.

After the regulation of Head of National Land Agency No. 4 of the year 1991 published, it is easier for the executors to implement the land consolidation. Nevertheless, the process is also experiencing major problems such as limited time and lengthy process even though the construction of roads and other facilities is not part of NLA function.

Land consolidation program, either compulsory or voluntary method, need the involvement of landowners in order to donate land for development such as road, schools, place of worships, etc. The decision to provide the infrastructure is based on agreement among the landowners. Moreover, the donation is not always land, it can be money. The decision to have variety in donation is related to the size of parcel. If the parcel is too small and cannot be reduced anymore, the landowner can donate an amount of money based on agreement.

This process, involving the decision of the participants, is the most essential part of land consolidation. As a result, there is a demand to improve the process of public participation in land consolidation so that it can be transformed into effective and practical public participation.

Land use

Based on the land use map, case study area is dominated with moor, grass and sand respectively. This condition creates jobs such as dairy farmers, farmers and sand miners. Moreover, in the last 5 years, the tourism sector grows rapidly. It is because the existence of interesting places such as Mbah Maridjan houses (key master of Mt. Merapi), Kaliadem bunker, Lava tour, Kaliurang recreational park, and many more.

Social Culture

Mt. Merapi is one of the active volcanoes in the world. The average of eruption happens between 2 -5 years (short period) and 5-7 years (medium period). The community living around Mt. Merapi knows that every year it will have small eruption and every 7-8 year big eruption will come. However, on the slope of Mt. Merapi, there are crowded settlements. People keep staying there. For these people who living there for centuries, they have already adapted to this situation. All the disaster events are blessed because it can fertile the soil.

When the eruption occurs, these people do not follow directly government's suggestion to evacuate immediately to a safer place, even after several eruptions. There are several reasons behind that condition. Based on their experience, in 2006, when they have already evacuated based on government's order, the eruption did not happen. Therefore, when in 2010 there is a warning to evacuate, the people are reluctant to move. They think the condition may be the same.

Another reason is they do not want to leave their cattle alone. The government also suggests to evacuate their cattle, but it is almost impossible since they have more than one. Cattails are a symbol of social prestige, so it is not surprising that people will look after them even they risk their life. According to them, they do not evacuate their cattle to a safer location because it may be hard for them to provide foods for the cattle in the evacuation site.

Also, the reason why they do not to be relocated is the feeling of insecurity of leaving their land, someone may take and occupy them or the government will acquire their land. Most of landowners still do not have a land certificate to prove their ownership strongly.

Moreover, according to them, the location of evacuation site is not close from their core activities. Consequently, they can not continue their works and oversee their property and cattles as well. Some people also believe that their area will not be affected by Mt. Merapi eruption. Here are the list of challenges to evacuate people.

Disaster Prone Area

In 2010, Department of Vulcanology and Mitigation has released the Disaster Prone Area (DPA) map to identify the level of the affected area. Based on DPA classification, DA is clearly the most dangerous area. The development policies of DA are as follows: (1) this area is not recommended for human settlements; (2) this area is highly recommended for forestry, conservation area and ecotourism; (3) infrastructures in this area are provided to support conservation area, ecotourism and disaster mitigation. The zero growth policy also applies to zone IA. DPA II is planned to become an area for limited expansion with a strict land use control. DPA I is safer than DPA II, but the risk of lava flood cannot be excluded. Pelemsari and Pangukrejo subvillages in Umbulharjo village, Kaliadem, Petung, Jambu and Kopeng in Kepuharjo village (study area) are belong to DPA III which means these areas must be free from residential.

The local government has stipulated local regulation No. 12 of the year 2012 concerning Sleman Spatial Plan, which is in Article 4 (2) mentioned that one of strategies for management of disaster prone area is developing evacuation route. Moreover, in Article 79 (b) mentioned that it is prohibited to add new public facilities in areas which directly affected by Mt. Merapi eruption and (d) it is prohibited to develop a new settlement in DPA III. The decision to prohibit the new amenities is due to the conformity. If this affected area is equipped with new amenities, people tend to stay there and it is not easy to ask people to move out. Even the government has built new residents for them, still some people are reluctant to move (Atmasari, 2014). If these people refuse to move, the government will not be responsible whenever the disaster occurs at later time. Also, the government will not compensate their loss. Furthermore, the Governor of DI Yogyakarta has emphasized that citizens who stay in DPA III will not get the facilities from government such as electricity and water (Rudiana, 2014).

Land Consolidation in Study Area

Land consolidation program in the study area is quite unique compared to other land consolidation programs. It is not about merging the fragmented land to have better agricultural production or developing rural areas. It emphasizes the boundary restoration due to missing border caused by volcanic ashes from Mt. Merapi eruption. The program is similar to a Tsunami event in Aceh, which lost its parcel boundaries.

Based on an interview with one of officials, in the early process of socializing land consolidation program, landowners refuse the land consolidation program.

They are afraid if their land must be handed over to the government. They suspect the program as a government's way to acquisite their land. The officials are trying to convince them by promising that they will get a land certificate to secure their tenure. After several meetings, the community finally agree to do the program.

Doing a land consolidation program for more than thousands of parcels in one year is not an easy task. A lot of work must be undertaken. Although the starting point is quite tough, along the way, people start to put trust into this program. Some people still doubt about it, but fortunately many parties support the program.

In order to discuss the process of land consolidation, a lot of meetings with local governments, universities and also with landowners are held either separately or together.

Process of Land Consolidation in Study Area

Land consolidation in study area is quite different with other land consolidation programs. This program is similar with other certification programs. One thing that make it different is that the participants discuss about the land donation for evacuation roadss. Although it is only 2% from total areas but at least this decision is based on agreement among them.

Evacuation roads is really needed since these villages are located in the slope of Mt. Merapi. This evacuation route will benefit the participants while they are working there and in case suddenly there is a warning about the eruption. These people are not living in the ex disaster area because the government has provided them a 100 m^2 house completed with village facilities such as a place of worship, a small amusement park, subvillage hall, stalls for their cattle, etc. in a safer location. Every household who affected from the eruption of Mt. Merapi will get this aids.

The process has been done well. All the process except the construction of roadss and other facilities has been taken seriously. In December 2014, the participants have got their land certificate. 1.687 parcels have been handed over to the participants.

Involvement of Public Participation in Land Consolidation

Land consolidation process in Indonesia may be similar from one province to another province as following the technical guidance. The difference among them is the objectives of the project. Mostly, land consolidation program aims to merge the fragmented land parcels so that it will have a bigger and better shape. In the study area, the aims of land consolidation program is to secure land tenure by restoring the boundary due to missing border caused by volcanic ashes from Mt. Merapi eruption.

Moreover, many landowners do not have a land certificate as the strongest evidence to prove land ownerships.

The process of land consolidation itself run pretty well. At the end of December 2014, public participants have got their land certificate without any significant matters. Although the process of public participation face a lot of problems, the participants enable to manage land donation for new evacuation route. It is based on their agreement.

Review from literatures, there is no formulation for conducting public participation effectively and practically. Yet several principles can be the key to carry out public participation well.

Missing Steps in Land Consolidation Procedure

The land consolidation procedures start with planning stage and end up in the implementation stage. The land consolidation procedure in Indonesia. The study implies that there is missing steps during the process. First, in the preparation stage, there should be a public meeting about land consolidation design. Nevertheless, the public meeting was held, but no discussion about the land consolidation design. In addition, in the implementation stage, there should be a construction of roads and other facilities, but in fact this step was passed. No construction during the process. While measuring the parcels must be undertaken in early process, the situation shows that the process occurred in the last stage. Hence, land consolidation procedure is not fully followed by the officials.

Low level of Public Participation

Public participation is an essential part of land consolidation process. For the majority of land consolidation process, public participation takes almost roles in every single stage such as the agreement to do land consolidation, the decision to donate land or money and the establishment of new public facilities. However, the research indicates the low level of public participation. It is shown in the public meeting where the participants tend to accept the decision made by the officials without arguing or asking for further explanation. It might happen when the level of understanding is low and no access to information.

The Lengthy Procedures & Limited Time for Conducting Land Consolidation Program

Since the duration to foster land consolidation in only one year, it is hard for stakeholders to manage the goal. For the participants, it is relatively quick to understand the program and their role as well. For the authorities, the ability to convince the participants, the preparation either tools or human resources for guiding the public participation process and lengthy procedures needed to be undertaken are not easy tasks. As a result, the goal which is certification might be achieved, but several things must be sacrificed or simply passed. In addition, there is still no public participation's legal framework which result the difficulty to guide the process although internal technical guidance is provided. The technical guidance itself does not elaborate in detail about public participation, only explaining the land consolidation process.

Confirmation of Hypothesis

The research hypothesis has been confirmed. The integration of provision sufficient information, legal framework for public participation and institutional capacity building is essentially needed to better the current situation. The research recognizes that there is not sufficient public information in present condition. Moreover, the absence of public participation's legal framework leads to the ineffective and practical process. The government has also failed to conduct public participation in terms of capability.

Mengevaluasi Kemubaziran Dataset Berbasis Parcel di Indonesia

Evaluating Redundancy of Parcel-Based Datasets in Indonesia

Nama	: Rizky Agung Nugroho
NIP	: 198209152008041003
Instansi	: BPN
Tahun Intake	: 2011
Tingkat Beasiswa	: Master Overseas
Program Studi	: Master of GEO Information Science & Earth Observation
Negara Studi	: Belanda
Universitas	: University of Twente

ABSTRAK

Kerangka studi kasus digunakan dalam melakukan penelitian ini. Kota Depok berfungsi sebagai studi kasus. Literatur memperhatikan komponen administrasi pertanahan, penggunaan dan pengguna pengelolaan informasi pertanahan, konsep dan penyebab redundansi, konsep SNA dan cara mengatasi redundansi ditinjau. Dari literatur, variasi jenis dan indikator terkait untuk mengevaluasi sejauh mana, penyebab redundansi dan peran jejaring sosial dikembangkan sebagai kerangka kerja. Wawancara adalah satu-satunya metode yang diterapkan untuk pengumpulan data primer. Pertanyaan wawancara didasarkan pada indikator yang dikembangkan. Dokumen yang terkait dengan kebijakan, peraturan dan proposal untuk mengatasi redundansi diperiksa untuk memperkuat pandangan yang diberikan oleh responden.

Hasilnya menunjukkan siapa aktornya, pengguna dan produsen kumpulan data paket. Dari pengguna itu bisa diketahui dari siapa mereka mendapatkan data dan dari produsen bisa diketahui siapa yang menggunakan datanya. Hasilnya juga mengungkapkan bahwa lebih dari satu organisasi menciptakan dan mengelola data berbasis paket untuk tujuan yang berbeda sesuai dengan mandat institusional mereka. Terjadinya pengulangan pembuatan dan pemeliharaan data yang melibatkan proses dan tugas tertentu yang harus dilakukan berdasarkan kebijakan dan peraturan tertentu dapat ditemukan. Standar yang berbeda dalam menghasilkan data diterapkan di kalangan produsen. Pertukaran data antar produsen juga terjadi. Hasilnya juga menunjukkan kesadaran diantara produsen soal redundansi. Terkait dengan peran jejaring sosial, data tersebut tidak mencukupi untuk mendapatkan kesimpulan apapun sehubungan dengan indikator yang telah dikembangkan.

Menurut kerangka konseptual redundansi yang digunakan, redundansi dibentuk oleh pengulangan dan manajemen, pengulangan proses dan tugas, dan manajemen untuk menangani replikasi dan penanganan kesalahan. Hasil evaluasi menunjukkan bahwa ketersediaan data yang memenuhi standar yang dapat digunakan untuk mencapai tujuan yang ditetapkan merupakan faktor yang dapat menyebabkan redundansi. Data redundan pada dataset berbasis paket dihasilkan melalui pengulangan tugas dan aktivitas yang terkait dengan penanganan data. Manajemen untuk mereplikasi data adalah untuk memastikan tersedianya data yang dapat digunakan untuk memenuhi tujuan yang ditetapkan.

Kata kunci: Redundansi, kumpulan data berbasis paket, Evaluasi

ABSTRACT

The frame of case study is used in conducting this research. Depok City serves as a case study. The literatures concern with the component of land administration, the use and users of land information management, the concept and cause of redundancy, the concept of SNA and the way to address redundancy are reviewed. From literatures, the variation types and the related indicators to evaluate the extent, the cause of redundancy and the role of social networks are developed as a framework. Interview is the only method applied for the primary data collection. The interview questions are based on the developed indicators. Documents related to the policy, regulation and the proposal to address redundancy are examined to amplify the views given by the respondents.

The results show who the actors are, the users and the producers of parcel based datasets. From the users it can be known from whom they obtain the data and from the producers it can be known who use their data. The results also reveal that more than one organization creates and manages parcel-based data for different purposes in line with their institutional mandates. The occurrence of the repetition on data creation and maintenance which involve certain processes and tasks to conduct based on certain policies and regulations can be found. The different standards in generating data are applied among producers. The data exchanges among producers also happen. The results also showing the awareness among producers about the redundancy issue. Related to the role of social network, the data is insufficient to derive any conclusions in relation to the indicators that have been developed.

According to the redundancy conceptual framework used, redundancy is constituted by repetition and management, repetition of processes and tasks, and management to handle replication and fault handling. The results of the evaluation show that the availability of data which meet to the standards that can be used to achieve defined objectives is a factor which can lead to redundancy. The redundant data on parcel-based datasets is generated through repetition of tasks and activities which related to the data handling. The management to replicate the data is in order to ensure the availability of data that can be used to meet the defined objectives.

Keywords: Redundancy, Parcel-based datasets, Evaluation

Land information systems (LIS) to manage land and property related data can be designed to serve one primary function or may be multifunctional and used by wide varieties of users (Dale & McLaughlin, 1999). According to Dale and McLaughlin (1999) the systems that focus on cadastral parcels, including multipurpose cadastres are the most important systems from land administration perspective. Because it registers rights to land, land administration needs an appropriate legal framework and transparent public administration structure (van der Molen, 2002). From a land administration perspective, Dale and McLaughlin (1999) state that the responsibility for collecting and coordinating all parcel based information can be mandated into a single authority. Theoretically, under a single authority, duplication can be reduced, standard in the data quality can be consistently achieved (Dale & McLaughlin, 1999) and the data reliability increased (Bandeira et al., 2010).

In Indonesia, creation of the cadastre is subject to a number of complex institutional arrangements. The National Land Agency of Indonesia (BPN-RI) has 21 functions in order to build a land administration system for the country (Republik Indonesia, 2006b). Some of these functions are: to formulate and implement policies in surveying, measuring and mapping activities, to register land rights, and to manage all data and information related to land. According to Presidential Decree Number 4/2006, BPN-RI is responsible to gather and manage cadastral parcel data and information. However, it is the local land office that's conducts the process of gathering, updating and maintaining cadastral data with supports from the central and provincial office. This disaggregation of responsibility means there is a potential for duplication of parcel based datasets.

Indeed, the issue of duplication for other thematic datasets was recently discussed. According to Geospatial Information Agency (BIG formerly known as Bakosurtanal), in Indonesia there are 18 thematic maps produced by different overlapping government bodies (Kompas, 2012). Fourteen government bodies create thematic maps. On the other hand, the occurrence of redundancy on the parcel-based datasets is not known yet. To tackle this redundancy issue, appropriate arrangements are needed by drawing up certain mechanism between government bodies. Though, before drawing up these mechanisms, the definition, the extent and the cause of redundancy needs to be known.

The notion of redundancy consists of duplication and repetition. Previous studies related to redundancy on spatial datasets show that multiple actors were involved in the collecting, processing and maintaining of the same spatial datasets and leading to duplication (Nyemera, 2008). Redundancy can bring negative and positive impacts. Waste of resources, efforts and time in the data collection, process and dissemination, differences in accuracy and poor data quality are the negative impacts of redundancy while the positive impacts include the provision of alternative sources of data (Nyemera, 2008). However, it is important to know what is perceived as redundancy in land administration domain before investigating more on this issue. It is also necessary to seek relation between the cause, the extent and which elements affect the redundancy phenomenon. The study of parcel-based datasets redundancy in Indonesia has not been conducted before. Researching in this area will benefit the BPN-RI or other any actors as producer as well as the users. A common understanding of what redundancy means and to what extent for land administration context in Indonesia will be developed. The outcome of this research will assist the decision and policy makers in formulating policy for the country.

This research will use redundancy definition by Schmidt (2006) as a conceptual framework. According to Schmidt (2006), redundancy is defined as system ability to continue operations in the case of component failures with managed component repetition. Repetition is defined as a process of repeating or being repeated. In the other words, repetition means something that happens in the same way as an earlier event. Management is known as the process of dealing with or controlling things or people. Management is also can be understood as activities in accordance with certain policies to achieve defined objectives. According to this redundancy definition, the management part is dealing with replication and fault handling. Replication can be defined as a copy or something that comes out as a result of reproduction activities. From database management perspective, replication is a result of storing the same data in multiple places. Fault handling can be described as system ability to deal with errors. Fault handling mechanisms must be able to handle exceptions to the systems to ensure that the process itself is resilient and can continue after failures occur.

By using the conceptual framework of redundancy described above, this research will try to figure the phenomenon of redundancy on parcel-based datasets. Larsson (1991) defines parcel data as an unique identification of land units and can be used for other records while Dale and McLaughlin (1999) state that land parcels have the same meaning as cadastral parcels. Cadastral parcel is defined as a tract of land, being all or part of a legal estate; is a uniquely delimited tract of land within which a coherent set of definable property interests is recognized (Dale & McLaughlin, 1999).

The role of the actors in the land administration domain can be treated as an entrance to study the redundancy phenomenon. Social Network Analysis (SNA) was used by Vancauwenberghe et al. (2011) to analyse the network of spatial data exchanges in Flanders, Belgium. This method treats the relation between actors as main research object. By applying this method, the flows of spatial data among actors can be identified. Social network analysis can provide insight into the impact of the arrangements between actors on the access to and exchange of spatial data. Who are the producers, the users or the suppliers of parcel-based dataset can be identified using this method.

The institutional arrangement of land administration system in Indonesia has set a mandate for BPN-RI to gather and manage parcel-based data, and register the parcel-based data attributes. BPN-RI's responsibility as a national agency is to provide cadastral data to all level of the governments in Indonesia and also other users for various purposes.

Many actors involved in land related activities can get benefit from land information system which characterize by properly organised of information collected and offers rapid accessibility (Lemmens, 2011). In the other hand, overlap and duplication of effort to gather and produce spatial datasets within government institutions should not be happen associated with authority related to the data. According to Dale and McLaughlin (1999) and Mohammadi et al. (2010), the reasons why this redundancy phenomenon emerges are largely related to the diversity of standards, unmet requirements of the users, issues on data sharing and accessibility, and the unavailability of spatial data infrastructure.

The occurrence of redundancy on parcel-based datasets in Indonesia is not clear. Therefore it is important to know to which extent the redundancy occurs and what the reasons behind the occurrence of this phenomenon.

The Extent of Redundancy

The discussion of the volume of duplicated parcel-based datasets can be started from which institution produce or manage the datasets. As stated on the Section 4.4.2 it can be known those institutions that produce and manage the data and the institutions who only manage the data. The parcel-based datasets itself are described on the Section 4.5. By looking on the Figure 4-1 and Figure 4-2, it can be known that there are two spatial data which differentiated by the institutions who responsible to generate the data. While through the Figure 4-3 it can be seen clearly that there are parcels that have two parcel identifiers which is used by two different institutions, parcel with NIB 03172 and with NOP 327800100100400840 for instance. Those parcels with different identifiers are used and produced under two different systems. It can be concluded that for the same parcels there are two datasets stored in two different systems.

The volume of duplicated data would be increased if the unregistered parcel is registered by the LO. The registration of a parcel will create a new set of data which consists of spatial and non-spatial data. The data will be stored in the SIMTANAS managed by the LO. Whereas the part of same parcel datasets, the spatial data, is also stored in the DPPKA system. It can be identified through the point that LO can obtain parcel maps, for the unregistered parcels, from the TO to complete the LO's registration based map. The volume of duplicated data also can be increased in case of DPPKA update their data using the data from the certificate of land rights submitted the tax payers. The data stated on the certificate, the name of the owner as the subject to tax and the extent of land as the tax object, is treated as valid data and used by the DPPKA to update the SISMIOP's data.

The parcel-based datasets are generated through a set of tasks with certain procedures that have been established as mentioned on the Section 4.6.2. On the land registration process, according to the regulations it requires field survey to conduct direct parcel measurement by surveyors to obtain spatial data. Later on the processing result of field survey data together with the result of examination of documents which submitted by the applicant will be processed according to the certain procedures and mechanisms. The processes to collect tax object data also consist of tasks to obtain tax object's spatial data. Although according to regulation it is possible to use remote sensing imagery, field survey to conduct direct parcel measurement also applied. The purpose of field survey is also for obtaining the data of subject to tax. After all the process is completed the data will be stored and managed under the SIMTANAS for the land registration process and in the SISMIOP for tax data collection and can be updated as needed. SISMIOP and SIMTANAS are information system that can handle both spatial and non-spatial data.

It can be known the presence of task repetition. Indeed in the two separated systems, repetition of works can be found. The processes to generate data and the process to handle the data under certain mechanisms are shown by both institutions. These processes to generate, to obtain and to maintain the data are certainly based on the defined objectives in accordance with the mandates of each institution. The data availability and to meet the specify requirements are the reasons behind the task repetition. The unavailability of data that can be used leads to a situation where the data should be generated. On the other hand, the available data which cannot meet the requirements that have been set out must be regenerated through certain process.

The existence of two different institutions that produce and manage parcel-based datasets in fact is also tried to be complementary. One party realize that their data is incomplete, while the other side recognize that their data is outdated. Both parties are aware of this situation. The Figure 4-3 gives an overview of the current data available on one village in the study area. The data available on DPPKA is not updated. For instance DPPKA still manages NOP 327800100100404110 as one single parcel, while in the Depok LO the parcel already subdivided and registered into four parcels. In line with the view by Hicks et al. (2006), the condition in Depok City shows that two growing independent information systems can lead to a situation where the information held by two organizations is isolated, incomplete and outdated. In a decision making process, primarily related to the public interest, accurate and reliable information plays a critical role.

The availability of up to date data is a necessity. The data accuracy, both for spatial and non-spatial data is an important concern for both parties. For the LO which has to provide legal certainty to the possession of land by individual or legal entity and give assurance regarding to the location, boundaries and the extent of the land, the term of accuracy is a vital factor. The legal certainty is expected to give tenure security and to support a well-functioning land market. On the other hand, the discrepancy of the extent or boundaries of a parcel can cause the uneasiness for the parties' related and sometimes lead to a legal action. For the DPPKA the utilization of accurate and up to date data cannot be ruled out. As a main source of local government income, the actual and accurate data for PBB and BPHTB are important things to notice. Fair land taxation is a key concern for government and citizen, local government as tax collector and citizen as taxpayer. The taxpayers pay the taxes according to their possession, and the government collect the tax according to the taxes that should be paid.

The presence of information management as an integral part on land administration is essential. The information management that can manage the process of data acquisition, preparation, exchange, dissemination, storage and retrieval of information, and link the different systems as well. Under the well-established information management regime which connects different systems and crosses institutional boundaries, the data exchange between parties can be done through a formal channel. The informal data exchange and dissemination which is based solely on personal relationships, through the direct contacts for instance, can be avoided. The repetition of tasks to generate and maintain the data would be reduced and the duplication of data can be minimized.

The Cause of Redundancy

From the result presented on Section 4.6, it can be known that two institutions have mandate related to the land parcel in Indonesia. BPN-RI has mandate to register land parcels and also provide recommendation to regulate the use of the land through its LOs in the city/district level. The DGT as part of Ministry of Finance has mandate to collect land tax through its local TO in the city/district level. The aggregation of mandates, where two institutions manage similar parcel-based data for different purposes would bring consequences. Each institution will work on certain policy and regulations in accordance with the mandate and objectives that have been set.

In generating spatial data, certain process and procedure must be performed to meet the defined standards related to the spatial level of accuracy. The Figure 4-3 as the result of overlay operation of maps on Figure 4-1 and Figure 4-2 shows the application of different standards in survey and mapping applied by the Depok LO and TO. From the result in Section 4.6.4 it can be known that the Depok LO generates spatial data with higher level of accuracy compare to the data generated by the Depok TO. It may be indicated that if the available data cannot meet the set standards, the option is to not use the data and likely to generate new data.

The application of different data standards, also can lead to barriers on the data sharing. Steps will be taken to adjust the unstandardized data to meet the requirement or to comply with the standards that had been set out by other organization. If the use of resources to make an adjustment or to modify is too high, it can be considered as an hindrance conferring to Croswell (2000). In that certain situation, party is likely to stick with existing standards rather than to adopt or modify other's standards. Interoperability and the maintainability are also the reason to apply the same standards. The establishment of a single national land database which will replace the current local database in every city/district LO requires the same protocol so that the data communication and transmission can take place without any hitch. By using the same standards, performance of the system can be relatively easy to maintain and monitor. That's why the flexibility on defining standards is important. Flexibility is in the sense that specific needs of users can be accommodated by the defined standards without overlooking the broader needs of other users.

The other users also mean other government organizations. Although separated by two different systems to manage parcel-based data, current situation shows that the Depok LO and the DPPKA have been exchanging the data but through informal channel. By regulations, the Depok LO can use the spatial data of the DPPKA to complete the registration based map meanwhile, the DPPKA needs to update their data. The use of informal channel which is not built specifically for disseminating, sharing and exchanging data among government institution is considered as a limitation. The use of informal channel requires effort to distribute, translate, interpret or modify the data to meet the specific needs. If the effort to take is considerably high compare to generate the same data, the decision would be merely to generate their own data and not to use the other's data. Moreover, one cannot rely on informal channel to exchange confidential data. In Indonesia, parcel-based data is considered as confidential data. Transparency in the term of misused of data and conflicts of interest among individuals can play a role.

When viewed from a hierarchical structure, the Depok LO lies in the bottom level under the provincial and national level. Data sharing and access, pricing policies, the defined standard and procedures, are set in the national level. With such arrangement, the Depok LO has to implement all those policies and procedures set in the national level. But on the other hand, the Depok LO must interact with local government organizations at the same level. From the result indicates that the interaction between the Depok LO and other local government organizations is likely facing complicated situation as stated by Sharon (1996). Depok LO cannot be certainly and flexibly establishing formal arrangement, in term of data access and sharing, with the other organizations who deals with parcel-based data. Sometimes to take a decision, coordination and communication with the higher levels must be conducted and it would take time. Whilst the local organization is not tied directly to the higher level organization hence it can work relatively flexible.

The current arrangement related to the land administration in Depok City is likely to happen in all city/regency in Indonesia. The LOs and provincial offices were established to conduct the duties and functions of the National Land Agency in the regency/city and provincial level (Republik Indonesia, 2006b). According to the Regulation of Head of BPN-RI number 4 year 2006, LOs which operate in the implementation level are coordinated by the provincial office (Republik Indonesia, 2006a). Meanwhile, policies, rules and regulations are made at the central level by considering the inputs and needs of the levels below it. Similar situation can be found with the TOs as part of a vertical institution under the Ministry of Finance. Formerly, to collect the PBB and BPHTB were the duties of TOs. Since the implementation of Law Number 28 Year 2009 about Local Taxes and Levies, all regency/city governments will take over the TOs' duties to collect the PBB and BPHTB.

The number of registered land or the land that has been legally determined is a problem encountered in Indonesia (Badan Pertanahan Nasional RI, 2010). That condition affects to the availability of land data and information. The availability of land data and information which continuously updated is one of the basic foundations for a nation development. The land data and information that can be used by society, governments and also the private sectors as the stakeholders. However, one should realize that no organization would have a neither complete nor up to date data. Resources are needed to generate and maintain the data. Emphasize should be on the view that all the data belongs to the state not owned by each institution. It may be a starting point to create a better access, hence enable the data and information utilization and exchange.

The Role of Social Network

Although there is no result available related to the social network analysis, this section attempts to discuss about land as an issue. The aim of implementing social network method is to know the degree of interaction related to the land among actors in the study area. The degree of interaction itself has three indicators to look at: applicability, interoperability and the frequency.

From the experiences gained by the researcher, give an indication that land remain as a sensitive issue in Indonesia. It is also expressed by some respondents. Information related to the land is confidential therefore cannot arbitrarily to be disseminated. One can say even to obtain information of land through the official institution is not easy. This issue is in line with the findings presented by Central Information Commission (KIP). KIP received many public complaints related to the difficulties in obtaining land related information (Berindra, 2012). According to the findings, BPN offices refused to provide information due to the discretion and even secrecy of the information. The subject matter is what kind of information related to the land is accessible to the public or can only be accessed by the land owner. This is related to the legal rules and regulations that govern the access of information. Set of requirements and procedures must be followed which give impression that official information related to the land is hard to obtain.

The difficulties to access or to obtain land related information may lead to a situation where one would not be easily sharing the information they have. The information held will be treated carefully because of the efforts that have been made to obtain such information. The greater the effort is given to obtain such information, the more information will be treated as confidential information.

Conclusion

To identify actors and their roles;

1. Who are the actors' related to parcel-based datasets? The actors related to parcel-based datasets is the actor who provide legal certainty to the possession of land by individual or legal entity and give assurance regarding to the location, boundaries and the extent of the land, manage the use of the land and collect taxes. Moreover banks and housing finance companies which provide loans using land and property as collateral, notaries, real estate agents, land surveyors and other actors who use details information are also the actor's related to parcel-based datasets.
2. What are actor's roles in the study area? The roles of the actors in the study area can be distinguished from the purpose of the use of parcel-based data. Depok LO providing service on land registration process, manage the land information and providing recommendation related to the use of the land which will be used by DISTARKIM. The DPPKA (formerly Depok TO) has a role to collect land and building tax. DISTARKIM is responsible for the city spatial planning and granting developing permit. The BIMASDA is responsible in developing and maintaining public infrastructures (road, bridge, and waterways). The village offices are providing the unregistered parcel data and information which is needed in a land registration process. Providing legal affair services are the role of notaries in the study are. Respondents related to the financial sectors have role in providing loans using land as collateral for personal and corporate sector. To develop housing are the role of housing developer. Role of surveyors are to conduct survey and mapping for Depok LO or other institutions.
3. What are the types of actor in the study area? From the result it can be known who the actors are: the users and the producers of parcel based datasets in the study area. The users found in the study area are in line with the users mentioned in the literature. The users of parcel-based datasets are varied from government institutions, notaries, financial sector such as bank and also the land surveyors. Producers of parcel-based datasets in Depok City are the Land Office (LO), the Tax

Office (TO) which since January 2012 their data of tax object and subject to tax and mandate to collect land tax has been transferred and shifted to the Revenue and Financial Management Office (DPPKA), and the Village Offices (VO). Each of the producers holds and manages parcel-based data for different purposes. The Depok LO manages parcel-based data for legalization purposes and the DPPKA manages the data for taxation purposes. The VO manages the unregistered parcel-based data which needed in the land registration process.

Persebaran Tanah Terlantar di Kabupaten Sukabumi Provinsi Jawa Barat

Distribution of Idle Land in Kabupaten Sukabumi, West Java Province

Nama	: Septina Marryanti P
NIP	: 198309252008042004
Instansi	: BPN
Tahun Intake	: 2011
Tingkat Beasiswa	: Master Local
Program Studi	: S2 Ilmu Geografi
Negara Studi	: Indonesia
Universitas	: Universitas Indonesia

ABSTRAK

Keterbatasan tanah dengan semakin bertambahnya jumlah penduduk yang menghuninya harus ditangani dengan optimal agar fungsi tanah tetap dapat memakmurkan. Namun, dalam perkembangannya jumlah tanah terlantar semakin meningkat setiap tahunnya. Penelitian Persebaran Tanah Terlantar dilaksanakan di Kabupaten Sukabumi Provinsi Jawa Barat. Tujuan dalam penelitian ini adalah mengetahui pola persebaran tanah terlantar di Kabupaten Sukabumi dan menganalisis faktor-faktor yang berpengaruh terhadap terjadinya pola persebaran tanah terlantar di Kabupaten Sukabumi. Batasan konsep tanah terlantar berupa sebidang fisik tanah yang tidak digunakan sesuai dengan peruntukan tanahnya. Analisa keruangan dilaksanakan dengan menggabungkan Peta Peruntukan Tanah dengan Peta Penggunaan Tanah untuk mendapatkan ketidaksesuaian antara kawasan peruntukan dengan penggunaan tanah atau tanah terlantar. Setelah didapatkan pola persebaran tanah terlantar, selanjutnya dilakukan analisa spasial dan statistik mengenai faktor-faktor yang mempengaruhi pola persebaran tanah terlantar dilihat dari faktor kependudukan, aksesibilitas dan penguasaan tanah. Hasil penelitian menyimpulkan tanah terlantar di Kabupaten Sukabumi mempunyai pola mengelompok, mengarah ke wilayah tenggara mendekati perbatasan dengan Kabupaten Cianjur, yakni pada bentuk wilayah bergunung atau kemiringan lereng curam, jenis tanah yang peka terhadap erosi, dan curah hujan yang tinggi. Variabel yang paling besar hingga yang yang paling kecil pengaruhnya terhadap pola persebaran tanah terlantar secara berurutan adalah jarak ke ibukota kabupaten, pertumbuhan penduduk, profesi konstruksi, profesi pertanian, kepadatan penduduk, dan penguasaan tanah Negara dikuasai.

Kata kunci: Tanah terlantar, penggunaan tanah, peruntukan tanah, sebaran spasial.

ABSTRACT

The people growth makes the limitation of the availability of lands. Thus, lands have to be managed optimally so the function of land to give the prosperity of people could be achieved. This research about the distribution of idle land was held in Kabupaten Sukabumi, West Java Province. The aim of the research is to know the distribution pattern of idle lands and analyze factors that effect to create distribution pattern of idle land. The limitation concept of idle land was a parcel of land that was not utilized according to its allocation. Spatial analyzation was used to integrate land allocation map with land use map to get incompability between the use and the allocation of land or idle land. After we got the pettern of idle land distribution, it was analyzed by using spatial analyzation and statistic to get factors that influenced the creation of idle lands from demography, accessibility and land tenure. The result of research showed that idle land in Sukabumi had an agglomerate pattern, approaching to southeastern area to boundary of Kabupaten Cianjur wich was mountainous area or steep slopes, lands on those areas were sensitive to erosion, and high rainfall. The most influenced variables to the less ones for the distribution pattern of idle lands sequentially were the distance to the capital of kabupaten, population growth, constructions occupation, agriculture occupation, population density and state land tenurship.

Keyword: Land allocation, land use, idle land, spatial distribution.

Masalah yang menyangkut hubungannya dengan tanah perlu ditangani dengan secara komprehensif, mengingat fungsi tanah sebagai sumberdaya yang sangat vital bagi pembangunan. Penelantaran tanah di pedesaan dan perkotaan, selain merupakan tindakan yang tidak bijaksana, tidak ekonomis, dan tidak berkeadilan serta juga merupakan pelanggaran terhadap kewajiban yang harus dijalankan para pemegang hak atau pihak yang telah memperoleh dasar penguasaan tanah.

Peraturan perundangan tanah terlantar telah disebutkan sejak berlakunya Undang-undang Pokok Agraria (UUPA) pada Tahun 1960. Keberadaan tanah yang memiliki fungsi sosial (Pasal 6 UUPA) harus diusahakan atau dimanfaatkan secara maksimal. Sebagaimana Pasal 10 UUPA menyebutkan bahwa setiap orang dan badan hukum yang mempunyai suatu hak atas tanah pertanian pada asasnya diwajibkan mengerjakan atau mengusahakannya sendiri secara aktif. Masyarakat baik perorangan maupun badan hukum yang mempunyai hubungan hukum dengan tanah berkewajiban memelihara, menambah kesuburan, serta mencegah kerusakan (Pasal 15 UUPA). Penelantaran terhadap tanah berakibat hukum, sebagaimana ketentuan pada:

1. Pasal 27 UUPA, yang menetapkan bahwa Hak Milik hapus bila tanahnya jatuh kepada Negara karena diterlantarkan;
2. Pasal 34 UUPA, yang menetapkan bahwa Hak Guna Usaha hapus karena diterlantarkan;
3. Pasal 40 UUPA, yang menetapkan bahwa Hak Guna Bangunan hapus karena diterlantarkan.

Ketentuan tersebut belum tegas menyebutkan kriteria sebidang tanah dapat ditetapkan sebagai tanah terlantar. Dalam penjelasan Pasal 27 UUPA hanya diterangkan bahwa tanah diterlantarkan jika dengan sengaja tidak dipergunakan sesuai dengan keadaannya atau sifat dan tujuan daripada haknya. Kurang jelasnya kriteria mengenai tanah terlantar menyebabkan ketentuan hukum tidak dapat dilaksanakan dengan baik.

Ketentuan mengenai tanah terlantar penting untuk ditetapkan, agar tindakan hukum terhadap penelantaran tanah dapat dilakukan. Dalam rangka mengatur penertiban dan pendayagunaan tanah terlantar, berlakulah PP Nomor 36 Tahun 1998 tentang Penertiban dan Pendayagunaan Tanah Terlantar. Selama 12 (dua belas) tahun sejak peraturan pemerintah itu berlaku, ternyata pemerintah belum mampu melaksanakan penertiban dari tanah yang diindikasikan terlantar. Pemerintah dalam hal ini BPN RI baru melakukan tahap rekapitulasi keberadaan tanah yang diindikasikan terlantar, dan belum menetapkannya sebagai tanah terlantar (Puslitbang BPN RI, 2009). Penetapan tanah terlantar terganjal Pasal 15 Nomor 36 Tahun 1998 yang memuat ketentuan Negara memberikan ganti rugi kepada bekas pemegang hak atau pihak yang sudah memperoleh dasar penguasaan atas tanah yang kemudian dinyatakan sebagai tanah terlantar. Jika tanah terlantar belum diganti rugi, maka pemegang hak atau yang menguasainya akan tetap mempertahankan tanahnya, sehingga penggunaan tanah tidak efektif dan Negara menjadi dirugikan. Ketidakefektifan PP Nomor 36 Tahun 1998 untuk dijadikan acuan penyelesaian masalah penertiban dan pendayagunaan tanah terlantar memandang perlu pengaturan kembali.

Selanjutnya, PP Nomor 11 Tahun 2010 mengenai Penertiban dan Pendayagunaan Tanah Terlantar lahir sebagai pengganti Peraturan Pemerintah Nomor 36 Tahun 1998, yang dipandang tidak dapat lagi dijadikan acuan penyelesaian penertiban dan pendayagunaan tanah terlantar. Semenjak ditetapkan peraturan tersebut pada tahun berikutnya (Tahun 2011) BPN RI berhasil menetapkan 19 SK Penetapan Tanah Terlantar. Namun demikian, jumlah tersebut tidak sebanding dengan usulan yang diajukan daerah yakni sebanyak 184 usulan tanah yang diindikasikan terlantar (Mulyanto, 2012).

Berdasarkan latar belakang dapat dikemukakan bahwa keberadaan tanah terlantar menyebar pada kondisi fisik dan sosial ekonomi yang beragam. Oleh karena itu, perlu adanya penelitian mengenai pola persebaran tanah terlantar dan faktor-faktor yang menyebabkan tanah terlantar tersebar pada lokasi tersebut. Sehubungan dengan itu, masalah penelitian dapat dirumuskan sebagai berikut:

1. Bagaimana pola persebaran tanah terlantar di Kabupaten Sukabumi?
2. Faktor-faktor apakah yang menyebabkan terjadinya pola persebaran tanah terlantar di Kabupaten Sukabumi?

Berkaitan dengan permasalahan pokok yang menjadi pertanyaan dalam penelitian, maka tujuan dalam penelitian ini adalah sebagai berikut:

1. Mengetahui pola persebaran tanah terlantar di Kabupaten Sukabumi.
2. Menganalisis faktor-faktor yang berpengaruh terhadap pola persebaran tanah terlantar di Kabupaten Sukabumi.

Pola Persebaran Tanah Terlantar

Penilaian terhadap kemiringan lereng, jenis tanah dan curah hujan harian rata-rata di suatu wilayah menentukan fungsi kawasan peruntukannya, yakni kawasan lindung, penyangga, dan budidaya. Kawasan budidaya berdasarkan kemiringan lerengnya dibedakan menjadi budidaya tanaman tahunan, dan budidaya tanaman semusim dan permukiman. Semakin besar kemiringan lereng, semakin peka jenis tanah terhadap erosi, dan semakin besar intensitas hujan harian maka akan semakin besar bobot yang diberikan. Jika dijumlahkan, nilai skor lebih besar dari 175 akan dikategorikan dalam kawasan lindung, untuk nilai skor 125 hingga 174 akan dikategorikan sebagai kawasan penyangga, serta untuk nilai skor di bawah 125 dikategorikan sebagai kawasan budidaya. Kawasan budidaya dibedakan lagi berdasarkan kemiringan lerengnya. Kemiringan lereng 8% sampai dengan 15% akan dikategorikan ke dalam budidaya tanaman tahunan dan kemiringan kurang dari 8% akan dikategorikan ke dalam budidaya tanaman semusim dan permukiman.

Kawasan lindung di Kabupaten Sukabumi seluas 363,41 Km^2, yakni sebesar 8,74%

dari luas kabupaten. Kawasan budidaya tanaman tahunan memiliki luasan terkecil jika dibandingkan dengan luasan kawasan peruntukan lainnya, yakni seluas 66,83 Km^2 atau 1,61% dari luas kabupaten. Kawasan lindung juga memiliki luasan yang tidak terlalu luas, yakni hanya 363,41 Km^2 atau 8,74% dari luas kabupaten, namun memerlukan perhatian khusus agar tidak sampai terjamah oleh manusia. Kawasan penyangga yang terletak diantara kawasan fungsi lindung dan kawasan budidaya, memiliki luas 1.436,86 Km^2 atau 34,54 % dari luas kabupaten. Kawasan terluas adalah kawasan budidaya tanaman semusim dan permukiman, yakni seluas 2.292,47 Km^2 atau 55,11% dari luas kabupaten, merupakan kawasan peruntukan yang dominan terdapat di Kabupaten Sukabumi.

Penggunaan Tanah

Penggunaan tanah di Kabupaten Sukabumi terbagi dalam 9 (sembilan) penggunaan, yakni hutan lebat, hutan belukar, padang rumput, perkebunan besar, kebun campuran, tegalan, sawah tadah hujan, sawah irigasi, dan permukiman. Penggunaan tanah Menggambarkan aktivitas penduduk setempat terhadap tanah sebagai tempat hidupnya. Masing-masing penggunaan tanah dapat dijelaskan sebagai berikut:

1. Hutan lebat adalah hutan dimana tutupan daun menghalangi masuknya sinar matahari, sukar untuk dilalui karena vegetasinya sangat rapat dan belum terjamah oleh manusia.
2. Hutan belukar adalah hutan dimana pohon-pohon besar yang kayunya baik sudah ditebang secara dipilih.
3. Padang rumput adalah tanah yang ditumbuhi alang-alang yang biasanya digunakan untuk penggembalaan ternak.
4. Perkebunan besar adalah daerah yang ditanami komoditi perkebunan seperti karet, kelapa sawit, teh dan coklat, dan sebagainya.
5. Kebun campuran biasanya berupa perkebunan yang ditanami dengan berbagai jenis tanaman, dan masing-masing tanaman tersebut tidak mungkin dipetakan secara terpisah.
6. Tegalan adalah tanah kering yang ditanami palawija terkadang juga ditanami padi, letaknya tidak terlalu jauh dari perkampungan.
7. Sawah tadah hujan adalah tanah sawah yang pengairannya bergantung pada air hujan.
8. Sawah irigasi adalah sawah yang mempunyai jaringan irigasi dimana saluran pemberi terpisah dari saluran pembuang agar penyediaan dan pembagian air ke dalam sawah tersebut dapat sepenuhnya diatur dan diukur dengan mudah.
9. Permukiman adalah seluruh tempat tinggal termasuk di dalamnya kampung/desa, emplasemen, dan kuburan. Terkadang dipetakan sekaligus dengan pekarangan yang ada tanamannya, seperti kelapa, buah-buahan dan sebagainya.

Kabupaten Sukabumi memiliki potensi sumber daya alam yang cukup kaya, potensi sumber daya pertanian terutama tersebar di bagian Utara aliran Ci Mandiri. Kondisi ini tidak bisa terlepas dari keberadaan Gunung Gede-Pangrango di sebelah Utara dan Gunung Salak di sebelah Barat. Selain karena didukung kondisi lembah dan lereng di kedua gunung tersebut yang melandai ke arah Selatan juga karena kondisi hutannya yang memberi daya dukung iklim dan tata air yang baik sehingga daerah pertanian di daerah utara relatif lebih subur dibandingkan daerah pertanian bagian selatan aliran Ci Mandiri.

Dalam sejarahnya, sejak dulu wilayah utara terkenal sebagai penghasil komoditi perkebunan berupa karet dan teh yang sempat memegang peranan penting dalam perekonomian negara di masa lampau. Sementara adanya dukungan tata air yang sangat baik, menyebabkan daerah utara berkembang menjadi daerah persawahan, usaha tani sayur mayur, peternakan dan budidaya ikan air tawar yang cukup potensial.

Persebaran Tanah Terlantar

Tanah terlantar di kawasan penyangga terluas ditemukan di Kecamatan Jampangtengah seluas 63,40 Km2 (12,49%), Segaranten seluas 52,82 Km2 (10,40%), dan Cidolog seluas 51,80 Km2 (10,20%). Gambar 5.3 memperlihatkan persebaran tanah terlantar di kawasan penyangga membentuk pola mengelompok sebagian besar pada bagian tenggara Kabupaten Sukabumi. Hal ini dikuantitatifkan dengan nilai T sebesar 0,45, yang menunjukkan bahwa tanah terlantar di kawasan penyangga adalah cenderung mengelompok.

Kawasan budidaya tanaman tahunan merupakan kawasan terkecil jika dibandingkan kawasan peruntukan lain di Kabupaten Sukabumi. Kawasan budidaya tanaman tahunan diperuntukkan bagi tanaman tahunan atau perkebunan yang manghasilkan bahan pangan maupun bahan baku industri. Tanah terlantar banyak dijumpai pada penggunaan tanah tegalan, sawah dan permukiman di kawasan budidaya tanaman tahunan. Luasan tanah terlantar tidak terlalu banyak dijumpai pada kawasan ini, sebanding dengan sedikitnya luas kawasan budidaya tanaman tahunan di Kabupaten Sukabumi.

Kecamatan dengan tanah terlantar terluas di kawasan ini adalah Kecamatan Segaranten seluas 6,19 Km2 (28,55%), Ciemas seluas 3,40 Km2 (15,66%), dan Lengkong seluas 3,22 Km2 (14,85%). Gambar 5.3 memperlihatkan persebaran tanah terlantar di kawasan budidaya tanaman tahunan membentuk pola mengelompok sebagian besar pada bagian tenggara Kabupaten Sukabumi. Hal ini dikuantitatifkan dengan nilai T sebesar 0,23, yang menunjukkan bahwa tanah terlantar di kawasan penyangga adalah Cenderung mengelompok.

Kawasan budidaya tanaman semusim dan permukiman diperuntukkan bagi tanaman semusim seperti tegalan dan sawah, serta perumahan penduduk. Tanah terlantar tidak dijumpai kawasan ini, karena penggunaan tanahnya telah sesuai dengan peruntukan tanahnya.

Tanah terlantar di Kabupaten Sukabumi merupakan gabungan antara tanah terlantar yang terdapat di kawasan lindung, penyangga, dan budidaya kawasan tahunan. Luas tanah terlantar di Kabupaten Sukabumi seluas 913,58 Km2 atau 21,95% dari luas kabupaten. Luas tanah terlantar di kawasan lindung seluas 384,09 Km2 (9,23% luas kabupaten), di kawasan penyangga seluas 507,79 Km2 (12,20% luas kabupaten), dan di kawasan budidaya seluas 21,70 Km2 (0,52% luas kabupaten). Jika digabungkan, tanah terlantar di kawasan Kabupaten Sukabumi terbanyak ditemukan di Kecamatan Tegalbeleud seluas 131,53 Km2 (14,40%), Jampangtengah seluas 123,37 Km2 (13,50%), dan Cidolog seluas 94,21 Km2 (10,31%).

Persebaran tanah terlantar lebih banyak mengarah ke wilayah tenggara mendekati perbatasan dengan Kabupaten Cianjur, dibuktikan dengan nilai T yang kurang dari 1 yang berarti cenderung mengelompok (clustered). Tanah terlantar mengelompok pada bentuk wilayah bergunung atau kemiringan lereng curam, jenis tanah yang peka terhadap erosi, dan curah hujan yang tinggi. Tanah terlantar terluas terdapat di kawasan dengan peruntukan penyangga. Hal ini perlu menjadi perhatian untuk pengelolaan tanah di kawasan penyangga, agar tidak menimbulkan bencana bagi penduduk setempat.

Faktor-faktor Penyebab Pola Persebaran Tanah Terlantar

Hasil uji korelasi variabel kependudukan dengan tanah terlantar. Uji korelasi menunjukkan angka p value untuk variabel kepadatan penduduk 0,085 dan variabel pertumbuhan penduduk 0,224. Dari hasil ini dapat disimpulkan bahwa variabel kepadatan penduduk dan pertumbuhan penduduk mempunyai p value < 0,25, yang artinya kedua variabel tersebut memiliki korelasi dengan terjadinya tanah terlantar, sehingga dapat dilanjutkan ke pemodelan *multivariant*.

Uji korelasi menguatkan analisa spasial bahwa terdapat korelasi antara kepadatan penduduk dan pertumbuhan penduduk dengan luasan tanah terlantar. Tanah terlantar dominan terdapat pada kepadatan penduduk yang rendah dan pada pertumbuhan penduduk yang sedang hingga tinggi. Kepadatan penduduk yang rendah menggambarkan masih sedikitnya jumlah penduduk yang bermukim di suatu kecamatan dibandingkan dengan kecamatan lain. Pertumbuhan penduduk yang sedang hingga tinggi menggambarkan adanya pertambahan jumlah penduduk yang bermukim di kecamatan tersebut selama sepuluh tahun terakhir. Hal ini mengindikasikan bahwa penduduk mulai merambah wilayah baru oleh karena keterbatasan mendapatkan tanah subur tingkat pertama. Tanah subur tingkat pertama telah dihuni dan dimanfaatkan penduduk, sehingga menjadi padat penduduk dan hanya sedikit mengalami pertumbuhan penduduk. Pada wilayah baru yang kurang subur inilah terjadi penelantaran terhadap kondisi fisik tanah. Keterbatasan kondisi tanah dipaksakan untuk digunakan memenuhi kebutuhan hidup, sehingga penggunaan tanah seringkali tidak sesuai dengan peruntukan atau penggunaan tanah yang melampaui batas. Jika tidak dikendalikan, maka dapat berakibat pada kerusakan tanah.

Profesi penduduk menggambarkan aktivitas penduduk dalam penggunaan tanah. Terdapat tiga bidang profesi yang berkaitan dengan pengelolaan tanah secara langsung yakni pertanian, pertambangan/ penggalian, dan konstruksi/ bangunan. Analisa keruangan menunjukkan bahwa sebagian besar tanah terlantar terdapat pada klasifikasi rasio profesi pertanian yang sedang dan beberapa pada rasio tinggi. Namun demikian, persebaran tanah terlantar kurang terlihat polanya pada rasio profesi bidang pertambangan dan panggalian. Tanah terlantar juga terlihat polanya tersebar pada klasifikasi rasio profesi bidang konstruksi/ bangunan yang rendah

Hasil uji korelasi variabel profesi penduduk dengan tanah terlantar. Uji korelasi menunjukkan profesi pertambangan/ penggalian memiliki angka p value > 0,25, yang artinya variabel tersebut tidak dapat dilanjutkan ke pemodelan multivariat. Sedangkan profesi pertanian dan konstruksi/ bangunan dapat melanjutkan ke analisa multivariat, dikarenakan memiliki nilai p value < 0,25. Kedua profesi tersebut memperkuat hasil analisa keruangan, yakni memiliki korelasi terhadap terjadinya tanah terlantar. Seberapa besar korelasi profesi penduduk dengan luasan tanah terlantar dapat diketahui melalui analisis lanjutan.

Uji korelasi menguatkan hasil analisa spasial bahwa terdapat korelasi antara profesi penduduk dengan keberadaan tanah terlantar, terutama untuk profesi di bidang pertanian dan konstruksi/ bangunan. Tanah terlantar banyak terdapat pada profesi pertanian dengan tingkatan sedang dan profesi konstruksi yang rendah. Profesi pertanian pada tingkatan sedang sebagian besar di bagian selatan memperlihatkan mulai banyaknya penduduk yang bekerja di sektor pertanian pada kondisi fisik tanah yang kurang tepat, yakni pada wilayah dengan kemiringan lereng curam, jenis tanah yang peka terhadap erosi, dan curah hujan yang tinggi. Penggunaan tanah untuk pertanian terutama sawah dan tegalan pada kondisi wilayah tersebut dapat mengakibatkan tanah terlantar. Profesi konstruksi/ bangunan pada klasifikasi rendah memperlihatkan bahwa tanah terlantar berada pada wilayah dengan pembangunan wilayah yang kurang pesat, yakni terutama pada wilayah-wilayah pedesaan yang minim akan pembangunan sarana prasarana wilayah.

Faktor Aksesibilitas

Aksesibilitas berperan penting dalam berkembangnya suatu wilayah. Keberadaan akses menjadikan antar lokasi dapat saling terhubung sehingga pada akhirnya akan tercipta aktivitas penduduk yang akan menentukan penggunaan tanah di suatu wilayah. Faktor aksesibilitas diwakili oleh keberadaan variabel jaringan jalan dan jarak ke Ibukota Kabupaten (Kecamatan Pelabuhanratu).

Jaringan jalan di Kabupaten Sukabumi terdiri dari jalan provinsi, nasional, kabupaten dan jalan desa. Jaringan jalan yang menghubungkan antar kecamatan masih belum tersedia. Jika dilihat secara spasial, tidak terlihat hubungan antara jaringan jalan dengan keberadaan tanah terlantar. Namun demikian, jika dilihat dari jarak Ibukota Kecamatan ke Ibukota Kabupaten dapat dianalisa bahwa kecamatan yang semakin jauh dari Ibukota Kabupaten atau Kecamatan Pelabuhanratu cenderung memiliki tanah terlantar yang luas.

Hasil uji korelasi variabel aksesibilitas dengan tanah terlantar. Uji korelasi menunjukkan angka p value untuk variabel jaringan jalan 0,421 dan variabel jarak ke Ibukota Kabupaten 0,001. Dari hasil ini dapat disimpulkan bahwa variabel jarak ke ibukota kabupaten mempunyai p value < 0,25, yang artinya variabel tersebut memiliki korelasi dengan terjadinya tanah terlantar, sehingga dapat dilanjutkan ke pemodelan multivariat. Sedangkan variabel jaringan jalan mempunyai p value >0,25, sehingga tidak dapat masuk ke model multivariat.

Adanya korelasi jarak ke Ibukota Kabupaten dengan luasan tanah terlantar menguatkan analisa spasial, yakni semakin jauh jarak dari Ibukota Kabupaten, maka semakin luas tanah terlantar. Tanah terlantar cenderung berada pada wilayah yang aksesibilitasnya jauh dari pusat pemerintahan. Hal ini dapat mengindikasikan tanah terlantar berada pada wilayah yang belum berkembang. Pada wilayah ini pengelolaan tanah belum optimal, ditambah dengan jarak yang jauh dengan pusat pemerintah cukup menghambat proses monitoring atas pengelolaan tanah. Tanah digunakan tidak sesuai dengan peruntukannya, sehingga menjadi terlantar.

Faktor Penguasaan Tanah

Faktor penguasaan tanah dijabarkan dalam variabel status hak atas tanah dan status kawasan hutan. Penelitian ini melihat pengaruh status penguasaan tanah dan status kawasan hutan pada wilayah tanah terlantar. Status hak atas tanah berupa Hak Guna Usaha (HGU), Hak Milik/ Tanah Adat, Tanah Negara Bebas dan Tanah Negara Dikuasai.

Hasil uji korelasi variabel penguasaan tanah dengan tanah terlantar. Uji korelasi menunjukkan status tanah hak guna usaha (HGU), hak milik/ adat, dan tanah negara bebas memiliki p value > 0,25, artinya ketiga variabel tersebut tidak memililki korelasi dan tidak dapat dilanjutkan ke model multivariat. Sedangkan untuk variabel tanah Negara dikuasai memiliki angka p value < 0,25, yang artinya variabel tersebut memiliki korelasi dan dapat dilanjutkan ke model multivariat. Status tanah Negara walaupun sudah dikuasai belum terdapat penegasan hak atas tanah, sehingga pengelolaan tanah kurang diperhatikan oleh pemilik. Hal ini sesuai dengan penelitian Silalahi (1982), bahwa pengelolaan tanah yang belum jelas pemegang hak atas tanahnya menjadi kurang diperhatikan pengawetan tanah dan airnya. Bahkan pada tanah Negara yang tidak dilakukan pengelolaan, mengundang masyarakat sekitar untuk okupasi atau menggunakan tanah secara illegal yang tidak sesuai dengan peruntukannya.

Tanah terlantar banyak dijumpai di kawasan non kehutanan seiring dengan luasnya tanah kawasan non kehutanan di Sukabumi. Tanah terlantar dijumpai di Kawasan Kehutanan dalam luasan lebih kecil dibandingkan kawasan non kehutanan, baik hutan produksi maupun hutan produksi terbatas. Sebagian besar tanah terlantar terdapat pada wilayah perbatasan kawasan kehutan dan non kehutanan. Wilayah perbatasan akan menjadi wilayah yang rawan akan penelantaran tanah jika tidak terdapat batas yang tegas antar kawasan. Ketidakjelasan ini berakibat pada ketidakjelasan subyek pengelolaan tanah, sehingga mengarah pada penelantaran tanah.

Hasil uji korelasi variabel kawasan hutan dengan tanah terlantar. Uji korelasi menunjukkan kawasan hutan memiliki angka p value sebesar 0,585 yang berarti p value > 0,25, yang artinya variabel tersebut tidak dapat dilanjutkan ke model multivariat. Walaupun, uji korelasi tidak menunjukkan adanya korelasi, namun secara analisa keruangan menunjukkan korelasi antara tanah terlantar dengan kawasan kehutanan, yakni pada wilayah perbatasan antara kawasan kehutanan dan non kehutanan.

Faktor-faktor Mempengaruhi Persebaran Tanah Terlantar

Jarak ke Ibukota Kabupaten memiliki pengaruh yang paling tinggi, karena akses dalam pengelolaan tanah menjadi tidak mudah. Hal ini juga didukung oleh jaringan jalan yang kurang memadai antar kecamatan, mengakibatkan penggunaan tanah untuk wilayah yang jauh dari daerah pusat (Ibukota Kabupaten) menjadi kurang optimal. Proses monitoring dan evaluasi terhadap penggunaan tanah oleh pemerintah daerah menjadi tidak maksimal dikarenakan aksesibilitas yang rendah.

Pertumbuhan penduduk yang tinggi di wilayah selatan mengindakasikan kecenderungan penduduk untuk mulai beralih mencari wilayah baru setelah tanah-tanah yang subur di wilayah utara mulai bernilai tinggi dan terbatas jumlahnya. Data ini didukung oleh tanah terlantar pada status penguasaan tanah Negara dikuasai, walaupun pengaruhnya tidak signifikan, namun memiliki pengaruh terhadap keberadaan tanah terlantar. Tanah Negara yang dikuasai oleh pemerintah yang berada jauh dari pusat pemerintahan cenderung untuk tidak dikelola. Pertumbuhan penduduk yang tinggi menjadikan penduduk mengokupasi wilayah baru termasuk diantaranya tanah Negara. Namun demikian, penggunaan tanah oleh penduduk kurang dimonitoring dengan baik mengakibatkan penggunaan tanah tidak sesuai dengan peruntukannya atau dengan kata lain terlantar.

Profesi konstruksi/ bangunan adalah penduduk yang bekerja di bidang konstruksi atau bangunan misalnya pembangunan jalan raya, jalan tol, gedung bertingkat, atau perumahan. Semakin tinggi profesi bidang konstruksi/ bangunan maka dapat dikatakan semakin tinggi pula perkembangan wilayah tersebut. Nilai negatif pada koefisien B mencerminkan tanah terlantar cenderung berada pada wilayah yang tingkat perkembangan wilayahnya tidak terlalu tinggi atau dengan kata lain biasanya berada pada wilayah pedesaan.

Wilayah selatan yang tadinya berupa hutan pada wilayah yang rendah mulai digarap dan dijadikan persawahan. Pertumbuhan penduduk yang tinggi juga berpengaruh terhadap pengolahan tanah yang lebih intensif. Wilayah yang sebelumnya berupa kebun campuran mulai diusahakan menjadi tegalan. Walaupun demikian, pengelolaan tanah menjadi tanah sawah dan tegalan jika tidak dilakukan pada karakteristik tanah yang tepat akan berakibat pada penelantaran tanah. Hal inilah yang mengakibatkan banyaknya profesi pertanian berpengaruh positif terhadap luasan tanah terlantar. Profesi pertanian menggarap tanah pertanian bukan pada kondisi tanah yang sesuai dengan peruntukannya. Hal ini perlu menjadi perhatian melalui upaya rehabilitasi, agar mempertimbangkan unsur kelestarian tanah dan menghindari rusaknya sumberdaya tanah melalui pembatasan eksploitasi tanah yang tidak diinginkan.

Kepadatan penduduk yang semakin rendah, maka semakin tinggi luasan tanah terlantar. Kepadatan penduduk yang rendah mengindikasikan wilayah tersebut masih belum banyak ditinggali penduduk. Penduduk yang ada lebih leluasa untuk mengelola tanah yang tersedia. Namun demikian, pengelolaan tanah yang tidak disesuaikan dengan kemampuan tanahnya akan berakibat pada terjadinya tanah terlantar.

Status tanah Negara walaupun sudah dikuasai rawan menjadi tanah terlantar apabila tidak dilakukan penegasan hak atas tanah. Ketidaktegasan inilah yang menjadikan pengelolaan tanah kurang diperhatikan oleh pemilik sehingga menjadi terlantar. Pengelolaan tanah yang belum jelas pemegang hak atas tanahnya menjadi kurang diperhatikan pengelolaannya. Pada tanah Negara yang tidak jelas penguasaannya seringkali dimanfaatkan penduduk secara illegal.

Berdasarkan analisa pada penelitian ini diketahui terdapat enam faktor yang bepengaruh secara bersama-sama terhadap keberadaan tanah terlantar. Faktor-faktor tersebut perlu menjadi perhatian agar terjadinya tanah terlantar dapat dicegah. Pemerintah yang memiliki kewenangan penuh dalam mengatur sumberdaya tanah perlu memberikan perhatian lebih terhadap wilayah yang rawan akan penelantaran tanah. Wilayah yang rawan terjadi tanah terlantar adalah yang jauh dari pusat pemerintahan, wilayah dengan kepadatan penduduk rendah yang memiliki tingkat pertumbuhan yang tinggi, wilayah yang kurang mengalami perkembangan wilayah, namun mulai berkembang profesi di bidang pertanian, serta pada tanah Negara yang belum dilakukan penegasan hak atas tanah.

Pemerintah perlu memperketat pengaturan akan penguasaan, pemilikan, penggunaan dan pemanfaatan yang terjadi di atas tanah beserta upaya evaluasi dan monitoringnya. Proses monitoring dan evaluasi dapat dipermudah dengan mencantumkan kewajiban yang harus dilakukan pemegang hak atas tanah baik dalam SK Hak atas Tanah maupun dalam Sertipikat Tanah. Pencantuman kewajiban-kewajian pemegang hak sebagai konsekuensi yang harus dilaksanakan sebagai pemegang hak atas tanah dapat mempermudah pemerintah dalam mengambil tindakan akibat penelantaran tanah. Semua itu ditujukan untuk mendapatkan tanah yang dapat lebih memakmurkan dan mensejahterakan.

Kesimpulan

Luas tanah terlantar di Kabupaten Sukabumi seluas 913,58 Km2 atau 21,95% dari luas kabupaten. Pola persebaran tanah terlantar mempunyai pola mengelompok, mengarah ke wilayah tenggara mendekati perbatasan dengan Kabupaten Cianjur, yakni pada bentuk wilayah bergunung atau kemiringan lereng curam, jenis tanah yang peka terhadap erosi, dan curah hujan yang tinggi.

Faktor-faktor yang berpengaruh terhadap terjadinya pola persebaran tanah terlantar di Kabupaten Sukabumi adalah kependudukan, aksesibilitas, dan penguasaan tanah. Variabel yang paling besar hingga yang yang paling kecil pengaruhnya terhadap pola persebaran tanah terlantar secara berurutan adalah jarak ke ibukota kabupaten, pertumbuhan penduduk, profesi konstruksi/ bangunan, profesi pertanian, kepadatan penduduk, dan penguasaan tanah Negara dikuasai.

Mengkuantifikasi Intensitas Penggunaan Lahan Pertanian Sistem Tebang dan Bakar Menggunakan Data Deret Waktu Penginderaan Jarak Jauh

Quantifying Land Use Intensity of Slash and Burn Agriculture Using Remote Sensing Time-Series

Nama	: Siti Hamim Latifah
NIP	: 198209272009032002
Instansi	: BPN
Tahun Intake	: 2013
Tingkat Beasiswa	: Master Overseas
Program Studi	: Master of Science Programme Geo-Information Science
Negara Studi	: Belanda
Universitas	: Wageningen University

ABSTRAK

Pertanian tebang dan bakar biasanya telah dipraktekkan di daerah tropis selama beberapa generasi. Selain fakta bahwa sistem ini penting bagi masyarakat lokal, namun telah berubah dari pola tradisional menjadi praktik yang lebih intensif yang dapat menurunkan ekosistem. Ada kebutuhan untuk mengembangkan metode otomatis yang mampu mengukur secara efisien intensitas penggunaan lahan dalam sistem tebang dan bakar, yaitu jumlah siklus pertanian dan panjang periode bera untuk menentukan pengelolaan penggunaan lahan yang lestari yang mengakomodasi pasokan makanan dan konservasi hutan. Dalam penelitian ini, kami telah mengusulkan dan mengevaluasi metode yang menggunakan *breakpoint* dengan kerangka *Breaks for Additive Season and Trend (*BFAST) pada rangkaian waktu Landsat dari tahun 1984 sampai 2014 untuk mendeteksi perubahan dalam sistem slash and burn. Metode ini diterapkan di hutan evergreen tropis di kotamadya Tefe dan Alvares, Brazil dimana ladang slash dan *burn field* ditempatkan di sepanjang sungai Amazon. Kami menguji delapan indeks vegetasi yang berbeda dan menemukan bahwa NDMI berhasil mendiskriminasi hutan (hutan tua dan hutan sekunder) dari ladang pertanian, di mana mengakui perubahan antara hutan dan lahan pertanian penting untuk menandai perubahan dalam sistem tebang dan bakar. Di sini, kami mengeksplorasi penggunaan algoritma deteksi perubahan pada tingkat objek untuk mendapatkan konteks perubahan spasial. Objek, yang mengacu pada jenis tutupan lahan, didefinisikan dengan menggunakan Analisis Berbasis Objek multi-temporal (OBIA). Validasi dilakukan dengan membandingkan prediksi sejarah penggunaan lahan (jumlah siklus pertanian dan panjang periode bera) yang berasal dari hasil penginderaan jauh dengan data pengamatan dari wawancara petani. Pendekatan kami dapat memprediksi data yang diamati dengan RMSE masing-masing 1,24 (kisaran 4) dan 1,35 tahun (rentang 10 tahun) untuk siklus pertanian dan jangka waktu bera, masing-masing. Sumber kesalahan kemungkinan besar disebabkan oleh kurangnya data Landsat dan ketidakteraturan pengamatan dalam rangkaian waktu Landsat, sesuatu yang tidak masuk ke daerah tropis. Sumber kesalahan lainnya adalah perbedaan waktu antara periode pemantauan dan perkiraan waktu petani. Secara keseluruhan, pendekatan berbasis penginderaan jarak jauh kami relevan untuk mengukur intensitas penggunaan lahan dalam sistem pertanian tebang dan bakar di hutan tropis. Pendekatan ini menawarkan cara yang mudah dan hemat biaya untuk memetakan intensitas penggunaan lahan dalam pertanian tebang dan bakar pada skala apapun (lokal, regional, dan lain-lain).

Kata kunci: Pertanian slash and burn, T*ime-series, Remote Sensing, Tropics, Normalized Difference Moisture Index* (NDMI), Analisis Citra Berbasis Objek Multi-temporal (OBIA), *Breakpoints, Break for*

ABSTRACT

Slash and burn agriculture has been commonly practiced in the tropics for generations. Besides the fact that this system is important for local people, it has been changing from the traditional pattern to a more intensive practice that could degrade ecosystems. There is a need to develop an automated method able to efficiently quantify land-use intensity within slash and burn system, i.e., the number of agricultural cycles and the fallow period lengths in order to define a sustainable land- use management which accommodates both food supply and forest conservation. In this research, we have proposed and evaluated the methods using breakpoints with the Breaks for Additive Season and Trend (BFAST) framework on Landsat time-series from 1984 to 2014 to detect changes within slash and burn system. The method was implemented in the tropical evergreen forest in the municipality of Tefe and Alvares, Brazil where the slash and burn field patches were located along the Amazonian river. We tested eight different vegetation indices and found that NDMI was successfully discriminated forests (old-growth and secondary forests) from agricultural fields, where recognizing the change between forests and agricultural fields is important to characterize changes in the slash and burn system. Here, we explored the use of change detection algorithm at the object level to derive the spatial context of changes. Objects, which refer to land cover types, were defined using multi-temporal Object Based Analysis (OBIA). Validation was done by comparing the predicted land-use history (number of agricultural cycles and length of fallow period) derived from remote sensing results with observed data from farmer interviews. Our approach could predict the observed data with the RMSE of 1.24 (range 4) and 1.35 years (range 10 years) for agricultural cycles and fallow period durations, respectively. The sources of error were most likely induced by a lack of Landsat data and irregularity of observations within the Landsat time series, something that is inevi in the tropics. Another source of error was the time differences between the monitoring periods and the farmers' approximation time. Overall, our remote sensing based approach is relevant to quantify land-use intensity within slash and burn agriculture systems in the tropical forest. This approach offers an easy and cost-efficient way to map land-use intensity within slash and burn agriculture at any scale (local, regional, etc.).

Keywords: Slash and burn agriculture, Time-series, Remote Sensing, Tropics, Normalized Difference Moisture Index (NDMI), Multi-temporal Object Based Image Analysis (OBIA), Breakpoints, Break for

Slash and burn agriculture, also known as swidden agriculture or shifting cultivation has been commonly practiced for generations in tropical forests (Fox 2000, Mertz et al. 2009, Hett et al. 2012). Slash and burn agriculture is characterized by cutting down the forest, drying the biomass and then burning it during the dry season. When the land is ready, farmers cultivate crops for a period of 1 to 3 years. After harvesting the crop, the land is left to fallow and secondary forest re-grows (Kleinman, Pimentel and Bryant 1995, Fox 2000). Traditionally, with appropriate fallow length, slash and burn agriculture is considered to be sustainable (Gehring, Denich and Vlek 2005, Mertz et al. 2009) and strengthen food diversity for local people (Hett et al. 2012). Within the slash and burn system, the length of time the land is left in fallow plays an essential role in maintaining the sustainability of the slash and burn agriculture system (Metzger 2003), as during the fallow period, weeds are suppressed, biomass accumulates and soil fertility is recovered.

In response to population growth and an increase in food demand, slash and burn agriculture is experiencing a shift from its traditional pattern toward a more intensified system (Dalle, Pulido and De Blois 2011, van Vliet et al. 2012). Fields are intensified by increasing the frequency of cultivation cycles and by shortening the duration of the fallow period (Dalle et al. 2011, Marquardt et al. 2013). Studies have shown that shortening of fallow period and increased frequency of cycles can reduce the sustainability of the system and lead to ecosystem degradation characterized by decreased forest regrowth rate, decreased soil fertility, decreased crop yield.

Along with increased concern about the potential of intensified slash and burn agriculture to cause forest degradation, understanding the spatial and temporal changes within this system becomes more important. Recently, changes in slash and burn agriculture concerning both the extent and the intensity have been identified locally; however, integrating the local data at regional level has proven difficult, particularly in Africa and South America (van Vliet et al. 2012). Conducting field surveys is often time consuming, expensive and involves various standards between different places. Hence, remote sensing is considered to have great potential to investigate the spatial and temporal behavior in slash and burn agriculture. The repea coverage of satellites makes it possible to capture sequential events within slash and burn agriculture. Remotely sense coverage of the sensor also makes it possible to investigate slash and burn activity without depending on site accessibility.

Nowadays, the availability of free remote sensing data; for instance, Landsat enhances the potential research related to slash and burn agriculture (Li et al. 2014). Of the freely available remote sensing data such as Landsat, Moderate-resolution Imaging Spectro radiometer (MODIS) and Advanced Very High Resolution Radiometer (AVHRR), Landsat is likely to be the most promising sensor to capture slash and burn agricultural changes as it provides the longest history (since 1972) in monitoring the globe, which enables it to perform historical analysis. With relatively fine resolution, 30m, and high acquisition frequency (16 days) Landsat is also considered appropriate in detecting slashing and burning events in the slash and burn cycle in a forest-agriculture mosaic landscape (Li et al. 2014). The main limitation of Landsat in the tropics is mainly associated with an inability to see through clouds; high cloud coverage in the tropics reduces the amount of usable data (Asner 2001, Li et al. 2014).

Slash and burn agriculture is an important system for local communities in the tropics (Hett et al. 2012), therefore, understanding the pattern related to the intensification of slash and burn agriculture is crucial to define sustainable land-use management that accommodates both food supply and forest conservation (Dalle et al. 2011). Despite progressive research related to slash and burn agriculture, quantifying the change in dynamics of this system remains difficult. This is particularly because of the complexity of the slash and burn system in relation to its temporal and spatial dynamics, mixed land cover types (crop field, secondary forests of different ages, old-growth forest), different fallow durations and the presence of different types of crops mixed in the fields (Mertz 2009). Furthermore, the current mapping products are mainly focused on assessing land use and land cover change (LULCC) in tropical landscape from the global/continental perspective, the availability of more detailed spatial scale mapping such as slash and burn agriculture is still limited (DeVries et al. 2015). Previous studies related to slash and burn agriculture using bi-temporal and chrono-sequential Landsat data (Inoue et al. 2007, Hett et al. 2012) emphasize the importance of further research making use of a remote sensing time series for mapping the land-use dynamics in slash and burn agriculture.

The use of remote sensing incorporated with change detection can potentially identify the dynamic changes in slash and burn agriculture (Mertz 2009, Hurni et al. 2013). Despite currently developed change detection methods for detecting forest disturbance (Huang et al. 2010, Kennedy, Yang and Cohen 2010, Verbesselt et al. 2010a), methods for quantifying land-use dynamics in the tropics are still limited. There is an urgency to develop an automated method able to quantify land use intensity in slash and burn landscape to enable data integration from local to regional level (van Vliet et al. 2012). This study proposes to use the Landsat time series and breakpoints detection method together with the Breaks for Additive Seasonal and Trend (BFAST) framework to identify the various events of slash and burn cycle through time and quantify the land-use intensity. BFAST framework has been proven to be able to characterize the changes by its magnitude and classify the spatial and temporal changes in the forested areas in south eastern Australia (Verbesselt et al. 2010a) and in the tropics (Devries et al. 2013, DeVries et al. 2015). This research especially focuses on mapping the behavioral changes that relate to intensification in slash and burn system; (1) the slash and burn cycle frequency and (2) the duration of fallow period. While the generic BFAST algorithm is developed at pixel based level, this research explores the possibility of applying it at the object based level.

Discussion

In this study, we investigated the feasibility of mapping the land-use intensity of slash and burn agriculture using a time-series vegetation index derived from Landsat TM/ETM+. We investigated 8 indices and found NDMI to be the most sui in characterizing different land-cover types in the study area. Breakpoints using BFAST framework was used to detect the dynamics changes in a slash and burn landscape. In order to obtain the spatial information, we implemented the change detection method at the object level, where we defined the objects using multi-temporal OBIA. Using RF classification, we interpreted the segmented temporal profiles resulting from the BFAST and derived the number of cycles and the fallow period length. Validation was carried out by confronting the cycle number and the fallow period length between remote sensing derived results (predicted) and reference data based on farmer interviews (observed). In this chapter the strengths and limitations of the methods will be discusses, as well as how relevant the methods were in being applied to monitor land-use dynamics in the tropics.

Vegetation Indices Selection

While NDVI has demonstrated to be a robust vegetation index used for monitoring land-cover change (Verbesselt et al. 2010a, Verbesselt et al. 2010b, Devries et al. 2013, Spruce et al. 2014), we found that NDMI performed better in discriminating the land-cover types in the study area (3). The NDVI characterized the land-surface by deriving the difference between the RED and the NIR reflectance. Vegetation, can be recognized by low value of the RED caused by leaf pigment absorption (especially chlorophyll) and the high value of NIR reflectance during photosynthesis (Tucker 1979, Wilson and Sader 2002). High value of NIR reflectance in the vegetation is strongly associated with the inner leaf structure reflectance (Tucker 1979, Wilson and Sader 2002). Similarly, NDMI also used the NIR reflectance, but use the SWIR rather than the RED to derive the difference between the two spectral bands (Wilson and Sader 2002, Sader, Bertrand and Wilson 2003). SWIR reflectance has known to be sensitive to water absorption, therefore, contrasting the differences between NIR and SWIR reflectance (NDMI) can provide information about leaves reflectance (inner leaves structure scattering) due to leaves water content absorption in the photosynthesis (Xiao et al. 2005).

The age of manioc fields, when we derived the VIs values, was 8 months old. At this stage, together with the early growing vegetation like weeds, the land-surface was completely covered by vegetation. NDVI, which mainly measures canopy greenness, seems to have not been able to differentiate between the reflectance of forests and manioc fields (3). This is probably because forests and manioc fields produce comparable chlorophyll, resulting in a similar value of NDVI. The limitation of NDVI is that it is saturated easily in dense vegetation like in the study area (Gao 1995, Huete et al. 2002). The NDMI, which is an index based on water content index, successfully notes the differences of reflectance between forest and manioc field. This is probably because forest canopies contain a more complex leaf structures compared with maniocs; hence they captured more water in their leaves. The higher the moisture content in the leaves, the higher the amount of energy absorbed in the SWIR region, resulting in a higher NDMI value in the forest (8, NDMI). Manioc fields, on the other hand, absorb less energy in the SWIR and produce a lower NDMI value than forests (8, NDMI). Here, the NDMI uses differences of leaf characteristics variation in absorbing water content to distinguish between the energy that was reflected by different vegetation. The NDMI was also reported to improve accuracy when detecting the vegetation biomass and forest disturbance than NDVI (Wilson and Sader 2002).

Our findings indicate the potential use of NDMI for discriminating different land-cover types in tropical ecosystems. However, in this research we were only interested in discriminating the two land-cover classes: forest (secondary and old-growth) and agricultural field (manioc), where NDMI can successfully discriminate between the two. To differentiate a more complex landscape consisting of various land-cover types, combining VIs (8) might be necessary.

Quantifying Land Use Intensity

To investigate the various periods and events in slash and burn agriculture, we implemented breakpoints (Bai and Perron 2003, Zeileis et al. 2003) using the seasonal trend model introduced in the BFAST framework (Verbesselt et al. 2010a, Verbesselt et al. 2010b). The BFAST framework prepares time series data that enables breakpoints to detect breaks and also the moment when the changes occurred in the time series. Here, we chose the simple trend model and did not include the seasonal component because: (1) our area is an evergreen tropical forest where seasonal changes are unlikely to occur; (2) our interest is to investigate the periods and events, within slash and burn agriculture, that are characterized by burning events (abrupt changes in temporal profile) where these types of changes are clearly explained by the trend components (Verbesselt et al. 2010a). The trend component of the BFAST that fitted the piecewise linear model enabled us to derive temporal profile characteristics (slope, coefficient, magnitude, etc.) of the changes. Thus, it allowed us to classify the time series profile and quantify the land-use intensity within the slash and burn system. We validated the derived remote sensing results by confronting the number of cycles and the length of the fallow period between the derived time-series result and information from farmer's interview in 29 ground truth GPS points. To further explore the possible errors that may have arisen from our methods, it is important to observe the prior similar approaches that have been developed in detecting forest disturbances. Our approach was based on the methodology developed by Verbesselt et al. (2010a). Using 16-day simulated MODIS NDVI, Verbesselt et al. (2010a) demonstrated that BFAST was able to detect and characterize various changes in the forest (forest harvesting, drought, and regrowth) in South Australia. The advantage of using MODIS data is that the high temporal resolution makes it possible to detect changes in a very short duration. However, MODIS data, has a spatial resolution of 250 – 500 meters, and is not sui for our context where we monitor land-use changes in small-scale land parcels. Therefore, we uses Landsat data.

Other change detection methods used to detect forest disturbances using full Landsat time-series were LandtrendR (Kennedy, 2010) and vegetation land tracker (VCT) (Huang, 2010). Kennedy et al. (2010) used yearly (relatively cloud free) Landsat images, while Huang et al. (2010) employed two Landsat images per year. Both methods have successfully demonstrated a great ability to monitor the various disturbances in forestry areas in the temperate forest in the USA. Nonetheless, using only annual or biennial Landsat might not suit well the Amazonian tropical forest, where the secondary forest recovery is fast and the ground is covered by vegetation in a couple of months (Jakovac et al. 2015). In addition, unlike the temperate forest, where potentially has many choices of Landsat data, in the tropics not many of them are existed because of persistent cloud covers (DeVries et al. 2015). Therefore it is necessary to include all the usable Landsat data, where more frequent images might cover the missing observation generated by clouds removal. Our methods were able to predict the cycle number and the length of time a field was left fallow with RMSE of 1.24 (range 4) and 1.35 (range 10), respectively (10). Here, we describe several factors influencing the remote sensing derived results in the validation:

The lack of observations, which is inevi for optical remote sensing in the tropics, seems to have been the greatest potential cause of error. Furthermore, the irregular observation availability within time series makes the model generate varying predictions (over-estimated, fit, and under- estimated), caused by the varied sensitivity on the h parameter. Also, the possible time frame difference between the observed and predicted data is likely to be another source of error. Above all, this method is likely to predict the land-use intensity in the slash and burn system in the tropics, by taking into account the approximate prediction error.

Multi Temporal OBIA

One advantage of object based mapping is that it offers a visual interpretation, which is more related with the real landscape compared to individual pixels, hence makes it easier for locals/experts to interpret (Raši et al. 2011). Our approach in defining slash and burn fields are following the methodology described by (Desclée et al. (2006), Duveiller et al. (2008), Raši et al. (2011)) using multi-temporal image segmentation. Our purpose was to extract all the possible slash and burn objects from all the study times to test the time series analysis performance at the object level. Furthermore, we aimed to automatically capture changes in the agricultural field boundaries over time. This method has performed better in capturing field changes over different times compared with when the changes were extracted after segmenting the images separately (Desclée et al. (2006), Duveiller et al. (2008)). s 16, 17, and 21 demonstrate that multi-temporal segmentation seems able to produce relevant map in mapping the dynamic changes within time-series in slash and burn system. This method offers a time-efficient method to detect field changes between times which involve great amount of time-series data like in this research.

Overall, the object based approach decreased the errors of prediction compared with the pixel based approach, with RMSE from 1.49 to 1.24 and from 1.69 years to 1.35 years for the cycle number and the length of fallow period respectively (10). Interestingly, in the individual assessment, object based did not always generate more accurate prediction compared to pixel based. While some cases showed object based predicted the number of cycles more accurate compared to the pixel based approach. other cases revealed that pixel based approach produced a more exact prediction. The higher accuracy in the object based approach probably due to the stronger reflectance of the object compared to individual pixel, decreased the sensitivity to noise effects. However, it is also possible to produce inaccurate object in the object based segmentation process, leading to generate an object that contained mixed land-use classes. Thus, the aggregated value of the object could have normalized changes (breaks) in some pixels inside the object.

Conclusions and Recomendations

In this research, we developed a method to quantify the land-use intensity in slash and burn agriculture in the Amazon tropical forest. The NDMI was found to perform best in discriminating agricultural fields from forests. Differentiating between agricultural fields and forests is important to detect changes between agricultural cycles and fallow periods within slash and burn system, therefore NDMI was used in time series analysis. Using breakpoints and the BFAST framework model, we employed full Landsat time-series data, from 1984 to 2014. We implemented the model to the potential slash and burn fields, and using 100 time series training data, we interpreted visually the resulting temporal profiles. Later, we classified all the slash and burn field using random forest classification algorithm. Using information from farmer interviews as the reference data, our methods estimate the land-use history in slash and burn system with an RMSE of 1.24 (range 4) for the number of cycles and 1.35 years (range 10) for fallow period length. It means that the model prediction could deviate more or less 1.24 from the real cycles (within the range of 1 – 4 cycles) and within the range of 1 - 10 years of fallow period durations, the model prediction could deviate more or less 1.35 years from the real fallow period durations. Errors were mainly generated by the limited usable data and irregularity of observations within the Landsat time series due to cloud cover. Another source of error was the differences in time between the study periods and the reference data period. Judging from the source of errors, which can mainly be seen as external factors, and the value of RMSE, our method is feasible in achieving our purpose to map the land-use intensity within slash and burn system.

Our approach seems relevant in being applied in the slash and burn landscape at any tropical evergreen forest where the slash and burn system exists. To date, methods to estimate slash and burn agriculture in the tropics are still needed, particularly at regional scale (van Vliet et al. 2012). Diverse spatial and temporal data standards on a local scale make it difficult to integrate to a wider level (van Vliet et al. 2012). By using freely available sensor data, our methods offer an easy and inexpensive way to map slash and burn agriculture. The use of remote sensing data also allows this method to be applied at any scale (local, regional, etc.).

The use of OBIA together with change detection algorithm is likely feasible to map the land-use changes in the study area. Although the individual temporal profile assessment revealed that object based did not always make a more accurate prediction compared to pixel based, the overall results indicated that object based decreased the error from 1.49 to 1.24 for number of cycles and from

1.69 years to 1.35 years for fallow period durations compared to pixel based. The result also showed that object based approach seems to be able to map the spatial pattern of land-use intensity within the slash and burn system (s 16, 17, and 20).

Memprediksi Penggunaan Lahan Kelapa Sawit setelah Penggundulan Hutan Menggunakan Parameter Spasial yang ada

Predicting Oil Palm Land Use Following Deforestation Using Available Spatial Parameters

Nama	: Sukmo Pinuji
NIP	: 198204102008042005
Instansi	: BPN
Tahun Intake	: 2013
Tingkat Beasiswa	: Master Overseas
Program Studi	: MSc Programme Geo-Information Science
Negara Studi	: Belanda
Universitas	: Wageningen University

ABSTRAK

Memahami karakteristik ekspansi pertanian, khususnya kelapa sawit, penting untuk mempelajari dampaknya terhadap tanah dunia. Pemodelan penggunaan lahan adalah alat yang bisa digunakan untuk membantu memahami proses kunci ekspansi kelapa sawit, untuk menilai keadaan saat ini, pengemudi, proses dan dampak ekspansi kelapa sawit. Dengan menggunakan kumpulan data spasial dari berbagai sumber, penelitian ini memodelkan proses perubahan penggunaan lahan dengan menggunakan IDRISI Land Change Modeller untuk memahami tindak lanjut penggunaan lahan kelapa sawit setelah peristiwa penggundulan hutan di Indonesia, dan juga untuk memprediksi kemana deforestasi kemungkinan akan terjadi karena proses ekspansi kelapa sawit. Metode Jaringan Syaraf Tiruan digunakan untuk membangun sub model selama periode pengamatan tahun 2000 - 2006, sedangkan metode *Markov Chain* digunakan untuk memprediksi penggunaan lahan di masa depan pada tahun 2009.

Hasil penelitian menunjukkan bahwa tren penebangan hutan dan ekspansi kelapa sawit aktual selama periode pengamatan dan prediksi berubah secara signifikan, sehingga mempengaruhi keakuratan model dalam memprediksi perubahan, terutama untuk kelas yang mendominasi perubahan setelah deforestasi, seperti kelas lain di Riau dan minyak kelas sawit di Kalimantan Barat dan Kalimantan Timur. Di Riau, kelas lainnya dinilai terlalu tinggi 47,63% lebih banyak dari yang sebenarnya. Di Kalimantan Timur dan Kalimantan Barat diprediksi dengan model 32,86% dan 54,57% kurang dari kenaikan aktual. Terlepas dari dua kelas tersebut, penggunaan lahan berikut setelah peristiwa penebangan hutan diprediksi lebih baik dari model, dan hanya memberikan perbedaan kecil dengan perubahan yang sebenarnya. Kami juga menemukan bahwa jarak dari perkebunan kelapa sawit yang ada adalah variabel yang paling signifikan dalam proses penggundulan hutan dan perluasan kelapa sawit. Kami menyimpulkan bahwa Jaringan Syaraf Tiruan dan Metode Rantai Markov berguna untuk memodelkan dan memprediksi perubahan penggunaan lahan setelah penggundulan hutan dan perluasan pertanian, namun gagal memperhitungkan faktor eksternal penggundulan hutan dan penguat ekspansi pertanian yang tidak disertakan selama proses pemodelan.

Kata kunci: penggundulan hutan, kelapa sawit, pemodelan perubahan penggunaan lahan, Jaringan Syaraf Tiruan, Perubahan Lahan, Modeller, ekspansi pertanian.

ABSTRACT

Understanding the characteristics of agricultural expansion, particularly oil palm, is important to study its impact on the world's land. Land use modelling is a tool that can be used to help to understand the key process of oil palm expansion, to assess the current state, the drivers, the processes and the impact of oil palm expansion. Using spatial datasets from different sources, this research models the process of land use change using IDRISI Land Change Modeller to understand the follow up oil palm land use after deforestation events in Indonesia, as well as to predict where the deforestation will likely to occur due to the process of oil palm expansions. Artificial Neural Network method was used to build sub-models during the observation period for the year of 2000 – 2006, while Markov Chain Method was used to predict future land use in 2009.

The results shows that the actual trend of deforestation and oil palm expansion during observation and prediction periods was change significantly, thus affecting the model accuracy in predicting changes, especially for the class that dominated the change after deforestation, such as other class in Riau and oil palm class in West Kalimantan and East Kalimantan. In Riau, other class were overestimated 47.63% more than the actual. In East Kalimantan and West Kalimantan was predicted by the model 32.86% and 54.57% less than the actual increases. Apart from those two classes, the following land use after deforestation events were predicted better by the model, and only gives small differences with the actual changes. We also found that distance from the existing oil palm plantations was the most significant variable in the process of deforestation and oil palm expansion. We conclude that Artificial Neural Network and Markov Chain Method are useful to model and to predict land use change following deforestation and agriculture expansion, but failed to account external factors of deforestation and agriculture expansion drivers that were not included during the modelling process.

Keywords: deforestation, oil palm, land use change modelling, Artificial Neural Network, Land Change Modeller, agriculture expansion.

Agricultural activities provide crucial services for human life through food demands, and also in economic development related with agricultural industries (Johnston and Mellor 1961, Hassan et al.2005, Etter, McAlpine et al. 2006). In line with population growth, the demand of food production is increasing, and requires agricultural industries to intensify its production, as well as to expand the production area. As a trade-off, environmental problems such as tropical deforestation, biodiversity loss, the degradation of soil quality and greenhouse gas emissions are rising

Many studies have been conducted to investigate and quantify the environmental impact of agricultural activities, and spatial analysis through land use change modelling has become a powerful tool (Lambin 1997, Lambin et al. 2000). Modelling land use change can provides a better understanding of the proximate and underlying drivers of land use change, to detect the trends and dynamics, to assess the impacts and to predict the future changes (Lambin 1997, Veldkamp and Verburg 2004). Many methods of spatial modelling of land use change have been developed, and often, the choice of method and level of detail in land use modelling are highly depending on the data availability and data quality (Veldkamp and Verburg 2004). Furthermore, with the advance development in GIS and remote sensing, spatial data are now extensively available in diverse formats and scales. The technology also allows non-spatial information such as crop yield, population density and other census-based data to be mapped and be presented spatially, and be provided in the form of thematic maps. Many GIS platforms also provide datasets that can be easily accessed. The easiness of access and the broad range of available data on various scales put open source data as a promising sources for GIS analysis, including the issues of land use change and agriculture expansion modelling.

While open source data are widely available, the challenges arise when the data have a different source and format, different processing technique and different spatial and temporal resolution, which often cause inconsistencies when the users try to compile several data for some purposes (Verburg et al. 2011). To compile and to select suitable data for land use change modelling are sometimes challenging. Often, global open source data with thematic information are available in coarse resolution. Moreover, global census-based maps, such as crop maps and yield maps usually lack of validation, where no independent remote sensing survey can be carried out to validate the data at time where they compiled, thus the level of accuracy of the data cannot be verified (Strahler et al. 2006, Kongsager and Reenberg 2012). This condition often raises the questions of for what can the data be used and are the specifications of the data available to meet the need of analysis. We study the possibility to associate the usage of available open source datasets to get a better understanding on the trend and dynamic of oil palm expansion in relationship with deforestation. Several open source data contain information that are considered as variables of land use change related with agricultural expansion and deforestation such as slope, elevation, protected area, and crop map were used (Boyd 1996, Lambin 1997, Overmars et al. 2003). Together with available data at national level provided by the government that are available in finer resolution, these datasets were incorporated to build a model of land use change for predicting oil palm expansion following deforestation. We choose oil palm as a representative of agricultural commodities, as this crop is mentioned as the fastest growing commodity in our study area (Sunderlin 1996, Sandker et al. 2007, Susanti and Burgers 2012). Since we incorporated some variables that we consider have complex relationship with the process of deforestation, we use Artificial Neural Network (ANN) as the method of land use modelling. This method is referred capable to model a nonlinear relationship within input variables and has been proved give better result compare to other methods, especially when the relationship between variables are unknown (Hill et al. 1994). Furthermore, we use Markov Chains method to build predictive land use change in our desirable year. These methods were available in Land Change Modeller (LCM) extension in IDRISI SELVA software developed by Clark Labs, Clark University, California, which was used in this research.

The overall aim of this study is to assess the possibility of using available open data as spatial parameters to predict oil palm land use following deforestation in Indonesia. To ascertain the main objective, there three sub-objectives as below:

1. Describe land use dynamics in the study area.
2. Design and test a model to predict deforestation event using available crop map dataset and indicators of suitability for conversion to agriculture.
3. Assess the accuracy and suitability of using crop maps to predict follow up land use following a deforestation event.

To answer our objectives, several research questions are defined below.

1. What is the trend and dynamic of land use change including deforestation events?
2. Are there any relationship between existing land use and follow up land use following deforestation?
3. Is the model can be used to predict land use change following deforestation?
4. What is the accuracy of the model?
5. Can we use the crop map dataset to predict follow up land use following deforestation?

The Trend and Dynamic of Land Use Change

We identify the trend and dynamic of forest change by investigating the change of forest polygon over the periods. We found that forest loss patterns in the study area were different within periods. In general, deforestation pattern in East Kalimantan and West Kalimantan increased during all the monitoring years, while in Riau, deforestation increased in the first and second period, but decreased in the third period. During 2000 until 2006, Riau has the highest clear cutting area amongst others, but in 2009 deforestation rate decreased significantly, from 262,064 ha into 190,778 ha, lower than East Kalimantan and West Kalimantan. In observation years, the pattern in East Kalimantan and West Kalimantan were steadily increasing, but during 2006-2009, West Kalimantan experienced intensive forest loss compared to the previous period. In this period, the area of deforestation in West Kalimantan increased 52% from earlier, put this province as the highest forest clearing area amongst others.

To get more insight on the trend of deforestation in the study area, we also observed followed land use after deforestation. We found that the trend was change during the observation and prediction periods. In Riau, deforestation was mostly followed by other class, while in East Kalimantan and West Kalimantan, this trend only occurred in the first period. In the first period, approximately 67% of the forest losses in East Kalimantan converted into other, while in the second and the third period, it was mainly turned into oil palm (42% in the second period and 72% in the third period). In West Kalimantan, in the first period, for about 44% of deforested area shifted into other, while in the second and the third period it were dominated by oil palm as for 65% in the second period and 47% in the third period. A significant increasing of agriculture class also showed in West Kalimantan during 2006-2009, with almost 41% of forest loss were converted into agriculture class. Figure IV.2 below illustrates the trend of shifting land use following deforestation, while Figure IV.3 shows the maps of forest change during 2000-2009.

As other class was derived from the aggregation of several land use classes as shown in Table III.2, we consider that other class was sensitively change into different land use over the periods, thus we called it as intermediate changes that might be also important to explain the process of oil palm expansion. Therefore, we pay attention for deforestation in 2000 followed by other class in 2003, particularly in Riau, by disaggregated this class into the original classification from the MoF. We focus on Riau as during the monitoring years, forests loss were dominantly changed into other class, with 91% of the total change in the first period, 84% in the second period and 41% in the third period. We traced back the process of forest-other conversion from 2000 until 2009 in the same polygons. We found that forest- other polygons in the first period were all belong to open land class. In 2003, the same polygons shifted into oil palm (14%), bushes/ shrubland (14.4%), agriculture (0.9%), crop forest (19.55%) and the remaining as open land (50.7%). In 2009, approximately 90% of the remaining open land still remains as open land, while the rest 10% were converted into crop forest, oil palm, swampy bushes and agriculture land use. This condition implies that forest conversion can be followed by intermediate change before being converted into certain land use, including oil palm plantation. Figure IV.4 below illustrate the intermediate change of other class in Riau.

We also implemented change analysis in IDRISI land change modeller. This step was a part of land use modelling process. The result of this step was the quantification of gain and losses area of land use change, and show which class that has the most contribution in certain change. The result can be used to identify the contribution of each class in increasing or decreasing the other classes, even though the history of a single polygon cannot be traced individually. Figure IV.5 show the result of gain and loss quantification from IDRISI change analysis panel. The value is in hectare. A negative value means area loss, while positive values area obtained. Forest contributes the most of increasing area of oil palm, agriculture and other. In Riau, forest conversions were mostly converted into other, while in East Kalimantan and West Kalimantan it was mainly converted into oil palm. The graphs also show that in the study areas, some of oil palm area were derived from other and agriculture class. Extensive conversion from agriculture into oil palm was found in West Kalimantan, covering an area of approximately 140,000 ha, and contributes to almost half of the total oil palm plantation. This trend of shifting cultivation also occurred in East Kalimantan and Riau, even though the number was not as extensive as in West Kalimantan.

Land Use Modelling and Prediction

In this research, we use several assumptions regarding to modelling land use change. Firstly, we assumed that the patterns of predictor variables were constant over the time. Secondly, we assumed that there were no policy changes at global, national or regional level that will affect the pattern of land use change during the observation and prediction periods, and the economic drivers were assumed to be stable. Thirdly, we assumed that the variables related to the government policies were implemented ideally. Nonetheless, the real process of land use change sometimes far from the assumptions, as confirmed by earlier researches (Waddell 2002). In reality, anthropogenic and topographic variables sometimes change with unpredictable patterns by some reasons such as natural disasters, economic growth, and the policy change or the policy that has not been implemented effectively.

Several possible explanations could explain why these striking differences occurred. In 2009, the world crude oil palm price increased up to 780$/ ton, has resulted in a large profit in oil palm business, and encourage the producers to expand their operation (Wicke et al. 2011). During this period, Indonesia intensively increased oil palm production by extending the plantation area, and after Sumatera that has been intensively expanded, future development was directed to Kalimantan and Papua (Susanti and Burgers 2012, Budidarsono et al. 2013). Furthermore, the establishment of the Decree of Agricultural Ministry No. 26/ 2007 allowing the large, capital-intensive companies to expand their production to invest in labour-intensive oil palm projects with smallholder farmers through various partnership schemes, such as contract farming or Perkebunan Inti Rakyat (PIR), also contributed in accelerating the expansion of oil palm plantation in Indonesia. The increasing of global oil palm demand, and the scheme of policy that allowed smallholders to access technology and market through partnership scheme, encourages the emergence of smallholder plantations in Indonesia. The census shows that during 2006-2009, the establishment of large oil palm plantations in Indonesia increased for almost 6% more than the previous periods, or increased 12,946,000 ha in total, while smallholder plantations increased for 70,450,000 ha (BPS 2014).These global market dynamics, followed by the change of national policies, are the examples of driver factors that failed to be modelled and predicted by classical model of land use change.

Reviewing to the third assumption, Indonesian government established several area as national parks that were designated as protected areas, with the assumption that no activities that potentially change land use are allowed. Therefore, in reality, Indonesia encounters the problem of rapid deforestations and forest degradations, including in conservation area (Jepson et al. 2001, Curran et al. 2004, Joppa et al. 2008). As an example, Curran et.al (2004) wrote that in Kalimantan, protected lowland forests declined by more than 56% of its total area, or more than 29,000 km2 during 1985 to 2001. Tesso Nilo National Park in Riau was also reported experienced intensive deforestation and forest degradation (Braun 2012), and oil palm expansion also reported occurred in this area (McLaughlin 2011). This condition leads to the incapability of the land use modelling to predict deforestation or oil palm expansion in the protected areas, as the model assign that there will be no changes occurred in these areas.

Artificial Neural Network for Modelling Land Use Change

In this research, ANN method was proven to give better result in predicting persistence rather than predicting the change (see Section IV.4). The accuracy of the model in predicting the persistence is 91%, 97% and 95% for Riau, East Kalimantan and West Kalimantan respectively, while in predicting the change, the model can only predict the change correctly of 0.06% for Riau and East Kalimantan, and 0.02% for West Kalimantan. However, this condition was confirmed by Pontius et.al (2004) and Pontius

Jr et.al (2008), as they mentioned that in many cases, the accuracy of the model will mainly came from the ability of the model to predict persistence rather than to predict the change. They also explained that this condition occurred since the changes were only occupied a small percentage of the total area, and it was acceptable that the accuracy of the model to predict the changes were lower than to predict the persistence.

Furthermore, some earlier studies have implemented ANN method to model land use change, and some of them have proved that this method performs better rather than other statistical land use modelling methods (Hill et al. 1994, Ahmed and Ahmed 2012, Ahmed et al. 2013). However, this method has been criticized as giving a 'black box' of ignoring the mechanisms that occur within the network, since the method dismissing the contribution of each input variable to the model output and the actual relationship between the input variables and the output layer is unknown (Gevrey et al. 2003, Mas et al. 2004, Olden et al. 2004). Even though the LCM package in IDRISI software provides a classical stepwise method to assess the degree of significance of each input variable, the results did not explicitly show the degree of correlation of each variable with the land use change, and the kind of contribution of each input variable to the model output, in which this information can be one of the most important part to understand the process of land use change (Gevrey et al. 2003). Therefore, for example, we cannot identify whether slopes has a negative or positive correlation with deforestation and the strength of the relationship, since the result from LCM only stated that this variable was significant or insignificant in deforestation process.

Elaborating Global Open Source Data

Several issues arise when we elaborated global open source data for land use modelling. The problems arise in relation with spatial resolution, temporal resolution and the accuracy level of the original datasets. The sub-chapter below describe about what problems arise during our research.

Spatial Resolution and Its Implications on Land Use Modelling

In this research, we elaborated several datasets from different source with different format and spatial and temporal resolution (see Table III.1 for the source and description of the datasets). Our datasets have resolutions that vary widely. Choosing the best resolution for land use modelling is somewhat challenging, as the input resolution will affect the result and determine the speed of the computation process. The choice to choose the best resolution is fully depending on the users, with the consideration of the scale and extent of the model and the purpose of land use modelling. So far, there are no specific methods of selecting the most appropriate resolution.

Some studies have proven on how the resolution of the input data will affect the sensitivity of the land use model. De Koning et al. (1998) stated that the patterns of land use/ land cover map can disappear or emerge, going from one scale to the other. He also mentioned that spatial autocorrelation will increase as the spatial resolution increase, and vice versa (De Koning et al. 1998). In terms of modelling land use, this statement has been confirmed by Rajan (2010), in which he proved that finer resolution of the input variable will give better predictive result of land use change, referring to his result in studying land use change in Imbabura Province, Ecuador. However, Pontius & Huffaker (2004) found that this not always be the case. In their work to develop validation techniques for modelling land use change, they mentioned that as the resolution of predictive model increased, it's percent correct generally will also increase, which mean that the accuracy of predictive model increase. Therefore, they introduced the concept of Null model and Null resolution to determine the most fair resolution in predictive model, which originally developed as validation techniques of land use modelling (Pontius et al. 2004, Pontius and Malanson 2005). Even though the concept of Null resolution was aimed to validate predictive land use model, this concept is potentially implemented as an approach to determine the most suitable resolution for input in land use modelling. However, our research was only limited to model land use change in a single resolution (30 m x 30 m), and did not test the effect of the change of resolution on the output as we consider that this chosen resolution can represent the pattern of land use our study area.

The Match between the Data in Describing the Real State

Secondly, the match between the data might raise problems. These issues might be sourced from the difference of spatial reference or temporal resolution. As an example, we found some discrepancies between LU maps and PA map. We consider that protected areas are treated as constrain variable, in which the possibility of this area to change into other land use is zero. In fact, we found that there were changes occurred in protected area, that can occurred because probably there were changes in the area, because the datasets have different spatial references that cause overlapping, or at the time the change occurred, the area has not been designated as protected area (we use 2014 version of protected area map). As an illustration, Tesso Nilo National Park in Riau was established in July 2004 with the area of 38,576 ha, and in 2009 was expanded into 83,064 ha by the government. The change of the extent might explain why there were changes occurred during observation period, and illustrated that the difference of when the data was produced can be the source of error in predicting land use change.

The Quality and Accuracy of the Original Data

The level of accuracy in original data might be the issues in elaborating open source data. To what extent of global open source data is reliable and accurate in representing the actual world will also affect the decision on to what extent and what scale of the datasets can be used for land use modelling. Census-based dataset, for example, has been criticized for inaccuracy, since no independent remote sensing survey data can be carried out to validate the data at the time where they compiled (Kongsager and Reenberg 2012). As an example, we used crop map datasets, which in this research we used OP map as part of crop maps as our reference data. These datasets have been used as reference of some analysis of land cover/ land use in global scale. For example, Licker et al. (2010) used the same crop maps to evaluate the yield gap for 18 different crops in global scale in relationship with the climate and agricultural management, and able to concluded the effect of different climate and management practice in contributing the differences of crop yield in global scale. Another example, Avnery et al. (2011) was also successfully counted the global reduction of agricultural yields of three different crops because of the elevated concentrations of surface ozone (O3) in the year of 2000 using these datasets (Avnery et al. 2011). However, as we tried to use OP map that was the part from crop maps dataset for analysis at sub-national level, the data did not show any significance in the model performance, and only perform significant in forest-other change in East Kalimantan. Furthermore, our investigation to look at the possibility of using this dataset to predict the next oil palm area after deforestation also showed no significant correlation. Here, Licker et al. (2010) confirmed that crop map datasets should be used to address issues related to their intended purpose, which is to compare regional crop yield patterns and agriculture area patterns, rather than to investigate it as individual grid cell. Moreover, Kongsager & Reenberg (2012) also mentioned that agricultural census-based map might have error that sourced from the under estimating of household-based production for self-consumption. Furthermore, since census data in crop map datasets were extrapolated to a limited biophysical and topographic parameter, it is possible that the datasets will give error due to the distribution of crop yields onto occasional grid cell with unsuitable conditions (Licker et al. 2010), in which our finding proved that the distribution pattern of oil palm dataset did not have any correlation with the existing of oil palm area based on the MoF dataset. Therefore, we found that oil palm dataset cannot be used to predict the next expansion of the oil palm area.

The Role of Agricultural Expansion in Land Use Change

This research proved that, among debates of whether oil palm plantation has been changing the world's forest, oil palm has proven to be the major driver of deforestation during 2000 – 2009, especially in East Kalimantan and West Kalimantan. In these provinces, deforestation was mainly followed by oil palm. For approximately 47% of the total deforested area in East Kalimantan was converted into oil palm, while in East Kalimantan was 42%. This means that approximately 315,336 ha and 267,040 ha of forests area were converted into oil palm in East Kalimantan and West Kalimantan respectively. Moreover, our finding in Riau also shown that agricultural expansion can be preceded by intermediate change, as explained in Figure IV.4. We found that once the forest has been cleared, in some cases, it does not necessarily followed by the opening of new oil palm plantation. We found that forest area that was converted into open land in 2003, 14% of them were converted into palm oil in 2006, while 51% of them were still remaining open land. Looking at the same polygons of remaining open land in 2006, 90% of them were still remaining as open land in 2009, while the rest of them were converted into other land use. It is unclear on what kind of land use right that follow the forest clearing in these polygons, but if it was followed by cultivation right, it is most likely that these lands should be converted into oil palm plantations, as this agricultural type is the most common type of commodities. Based on Indonesian Agrarian Law, as the land was not cultivated in accordance with the purpose, this land can be categorized as abandoned land and the right can be revoked by the Government. The occurrence of abandoned land in Indonesia has been claimed to give adverse effect economically and environmentally (Sigit 2012). In Riau itself, there are approximately 55,451 ha of cultivation right that have been abandoned in 2010 (NLA 2010). Therefore, we conclude that not only as the driver of deforestation, agriculture expansion also potentially drives the occurrence of abandoned land, in which this issue is still rarely investigated.

Moreover, look through at Riau case, even though many researches claimed that oil palm plantations were not always converted from forestland and in some area only have a limited contribution to the total forests loss in Indonesia (Koh and Wilcove 2008, Butler 2011, Susanti and Burgers 2012), which will also be found if we directly interpret the result of land use change detection, our study found that further analysis on the history of land use change is necessary to get more insight on direct or indirect process of agriculture expansion in changing the world's forest. As an example, Budidarsono et al. (2013) also mentioned that the establishment of large-scale oil palm plantations strongly influences the rate of land development in a region by speed up the development of infrastructure and stimulates the growth of the local economy. This condition is indirectly affects the emergence of non-agricultural activities in the area as the consequences of economic growth, such as trade, home industry and services, in which agriculture expansions are responsible for. Our model, unfortunately, have the limitation in explaining this continuous effects of agriculture expansion. Therefore, we suggest that, future study of the land use change history might useful in understanding the process of land use change related to agriculture expansion.

Future Study of Modelling Land Use Change

Summarized the explanations above, some improvements might be implemented for future study. First, as we only model land use change in single resolution (30 x 30 m), and even though the original resolution of the datasets determines most of the result, future study on to what extent of input resolution will affect the result of the land use model, and how to choose the best fit resolution of the input model might give benefit for future improvement of modelling land use change. Here we suggest that the concept of null resolution from Pontius et.al (2004) and Pontius and Malanson (2005) can be improved to be used as the method to choose the optimal resolution in land use modelling.

Furthermore, following the result from Licker et al. (2010) on the investigation to analyse the yield gap of crop map, even though the research was carried out on the global scale, might also be used to explain the yield gaps in sub-national level and furthermore to explain the underlying drivers of oil palm expansion. In our study area, we found that the three provinces have relatively large difference of the maximum pixel values. This also indicated that they have different oil palm yields, and ignoring the factor of climate, the gaps can be sourced from the differences of soil quality and human management, including irrigation, fertilization and other planting practices (Licker et al. 2010), and also the different agricultural practises. Looking at these reasons, OP map, even though mostly performed as insignificant variable in our method of land use modelling in our study area, provides an opportunity to compare crop yields at national or sub-national level, and investigating the drivers of oil palm comprehensively.

In relevance with modelling land use change using statistical approach, we suggest that, given the limitation of land use change modelling with several assumptions of some behaviour of the variables, rather than literally interpret the prediction result as an absolute future change, it should be seen as a tool to give the insight of the area that are vulnerable to change. Apart from the issue of accuracy, this interpretation can be used as reference for the next policy and monitoring program of deforestation and land use change.

Conclusion

Agricultural activities have had a long history in changing the world's surface. Even though not always be the case, agricultural expansions are often became one of the main causes of deforestation, and has been accused responsible for environmental degradation, in global and local scale. Nonetheless, population growth and the increasing of world food demand put agriculture expansion become inevitable. Therefore, understanding the dynamic of agriculture expansions is important. Our study shows that oil palm activities were proven responsible for the most change of land use in our study area. We also found that sometimes, deforestations involving agriculture expansion was followed by intermediate change before it were established as plantation areas. Furthermore, our result shows that distance from existing oil palm plantation was the most significant variable in the process of deforestation and agriculture expansion.

Furthermore, we found that land use modelling can be used as an effective way to capture the dynamics of agricultural activities. Artificial Neural Network, integrated with Markov Chains method can be used to model the change of land use following deforestation, particularly for oil palm, and can answer the questions which might arise on what change, where change, the extent of change and what will be the next condition. However, our results show the limitation of a statistical model in predicting land use change. The model cannot capture the dynamic of deforestation drivers that which were not included as model parameters. Here, we found that the rapid expansion of oil palm that mainly driven by global market cannot be captured by the model. Therefore, land use change is a complex system that cannot be captured only by a single method of land use modelling.

Our study also proved that integrating open source datasets for modelling land use change purpose is possible to be implemented, even though integrating global scale data for local analysis may arise several problems. The issue of aggregation level caused by the resolution of the datasets raises the problem of loss of information, which at some point made the dataset perform insignificantly when it was applied for the analysis at a more detailed level. Furthermore, we conclude that the statistical modelling method should be considered as a tool, which cannot be interpreted as the real representation of the state, but rather to give the introduction on what process that occurred in land use change and cannot be solely considered as an absolute explanation. To get the more comprehensive explanation on the real process of land use change, an interdisciplinary analysis should be implemented.

Perbandingan Metode Menurunkan Kelembaban Tanah Downscaling Smos dengan Menggunakan Mode Data Visible, Dekat Inframerah, dan Termal Inframerah

A Comparison of Methods for Downscaling Smos Derived Soil Moisture Using Modis Visible, Near Infrared, and Thermal Infrared Data

Nama	: Tatag Bagus Narendra
NIP	: 198109092009031002
Instansi	: BPN
Tahun Intake	: 2013
Tingkat Beasiswa	: Master Overseas
Program Studi	: Master of Spatial Information Science
Negara Studi	: Australia
Universitas	: University of Melbourne

ABSTRAK

Informasi kelembaban tanah yang diperoleh dari satelit penginderaan jarak jauh microwave biasanya memiliki resolusi spasial kasar, yang kurang sesuai untuk banyak aplikasi hidrologi regional. Oleh karena itu, banyak metode *downscaling* telah dikembangkan untuk memperbaiki resolusi spasial produk kelembaban tanah satelit sambil mempertahankan kinerjanya. Penelitian ini bertujuan untuk membandingkan dan membandingkan produk *downscaling* dari BEC-Aqua, BEC-Terra, dan DISPATCH. Produk ini juga dibandingkan dengan SMOS L3 untuk menyelidiki peningkatan kinerja produk terpilah terhadap data resolusi kasar. Pengukuran in situ terdiri dari 49 stasiun yang didistribusikan di dalam wilayah studi di Indonesia Periode 1 tahun (Juli 2010 sampai Juni 2011) digunakan untuk validasi. Hasil penelitian menunjukkan bahwa metode *downscaling* memperbaiki variabilitas spasial SMOS tanpa penurunan kinerja dan akurasi yang signifikan. Berdasarkan kelayakan temporal, kinerja produk terpilah relatif sebanding dengan R berkisar antara ~ 0,3 sampai 0,9 dan RMSD yang tidak bias berkisar antara ~ 0,02 sampai 0,1 m3 / m3 (p-value <0,05 untuk interval kepercayaan 95%). Perbaikan dalam R berkisar antara ~ 0,02 sampai 0,14 untuk BEC-Aqua dan BEC-Terra, dan ~ 0,01 sampai 0,10 untuk nilai DISPATCH terhadap nilai SMOS R. Meski validasi harian dan musiman mendapatkan hasil yang kurang menggembirakan, masih relatif mencerminkan kinerja masing-masing produk. R dari semua produk serupa di musim panas dengan R ~ 0.3 dan RMSD yang tidak bias optimal pada musim gugur dengan kisaran ~ 0,06 sampai 0,09 m3 / m3. Mengenai penilaian berdasarkan penggunaan lahan, elevasi, dan kemiringan, ditemukan bahwa semua produk terpilah sesuai dengan baik di daerah datar dengan jenis lahan penggembalaan (penggembalaan padang rumput yang dimodifikasi), dengan kisaran R ~ 0,5 sampai 0,8 dan RMSD tidak bias antara ~ 0,04 dan 0,08 m3 / m3. Dengan demikian, penelitian ini mendukung penggunaan ini metode downscaling untuk memperbaiki resolusi spasial SMOS hingga 1 km sesuai dengan kebutuhan aplikasi hidrologi regional skala-halus.

ABSTRACT

Soil moisture information acquired from microwave remote sensing satellites typically have a coarse spatial resolution, which is less suitable for many regional hydrological applications. Therefore, numerous downscaling methods have been developed to improve the spatial resolution of satellite soil moisture products while maintaining its performance. This study aims to compare and val- idate the downscaling products from BEC-Aqua, BEC-Terra, and DISPATCH. These products also being compared with SMOS L3 to investigate the perfor- mance improvement of disaggregated products against coarse resolution data. In situ measurements comprising of 49 stations distributed within the study area in 1 year period (July 2010 to June 2011) is utilized for validation. Results show that the downscaling methods improve the spatial variability of SMOS without significant degradation of the performance and accuracy. Based on temporal val- idation, the performances of disaggregated products are relatively comparable with the R ranged from ~0.3 to 0.9 and unbiased RMSD ranged from ~0.02 to 0.1 m^3/m^3 (p-value < 0.05 for the 95% confidence interval). Improvements in R range between ~0.02 to 0.14 for BEC-Aqua and BEC-Terra, and ~0.01 to 0.10 for DISPATCH against SMOS R value. Although daily and seasonally validation obtain less encouraging results, it still relatively reflects the performance of each product. R from all the products are similar in summer with R ~0.3 and unbiased RMSD optimal in autumn with the range of ~0.06 to 0.09 m^3/m^3. Regarding val- idation based on land use, elevation, and slope, it is found that all disaggregated products agree well in the flat area with the land use type of pasture (grazing modified pasture), with the range of R ~0.5 to 0.8 and unbiased RMSD between ~0.04 and 0.08 m^3/m^3. Accordingly, this study supports the use of these downscaling methods to improve the SMOS spatial resolution down to 1 km complying the needs of fine-scale regional hydrological applications.

Understanding the Earth as an integrated system needs various aspects including the ability to determine spatial and temporal distribution of soil moisture. Although soil moisture comprises only a small percentage (~0.001%) of the total water (Petropoulos, 2013), it is of essential to many hydrological, biological and biogeochemical process (Liang et al., 2012). Soil moisture is an important part in regulating the exchange of water and heat energy between the land surface and the atmosphere through evaporation and plant transpiration. It has several supplementary effects on climate process through its impact on the partitioning of the incoming energy in the latent and sensible heat fluxes, particularly on boundary layer stability, air temperature, and in several parts on precipitation (Liang et al., 2012).

Soil moisture is referred to the water contained in the pores between soil particles in the unsaturated soil zone(Seneviratne et al., 2010). Water contained within the upper 5 cm of soil is commonly called surface soil moisture, while root-zone soil moisture re- fers to the water that is available to plants, typically in the upper 200 cm of soil. Soil moisture content usually stated as a dimensionless ratio of two masses or volumes. It is also expressed as a ratio of a mass of water per unit volume of soil (Pietroniro et al., 2013). In the scale of 100, these dimensionless ratios can be reported as percentage or decimal fractions (Petropoulos et al., 2015).

Soil moisture information is beneficial to a varied commercial organizations and governmental agencies dealing with weather and climate, runoff potential and flood control, soil erosion and slope failure, reservoir management, geotechnical engineering, and water quality, agricultural productivity, human health, and national security (Liang et al., 2012),(Entekhabi et al., 2010),(Piles, 2010).

Measurement methods of soil moisture content are conducted either direct or indirect which can be obtained through in-situ measurement as well as acquisition of remotely sensed data. In-situ measurement provides high spatial and temporal resolution due to its local scale. However, several measurements are usually destructive because it needs soil removal from the field to be analyzed in the laboratory. Besides that, this method is time-consuming and impractical (Liang et al., 2012). Mostly, In-situ soil moisture measurements are expensive and often problematic. There is no large area of soil mois- ture network measuring soil moisture content which provides high spatial and temporal resolution, and multiple depths that is necessary for a wide range of applications (Houser et al., 1998). Compared with in-situ measurement methods, recent technolog- ical advances in satellite remote sensing provide a variation of techniques to estimate soil moisture content as well as its spatial coverage and high frequency.

Estimation of soil moisture content using optical remote sensing data can be con- ducted by analyzing the relationship of soil surface reflectance and soil moisture con- tent. It is generally based on empirical spectral vegetation index, which indicates veg- etation spectral properties and degree of vegetation moisture stress. In that way, indirect estimation of soil moisture content can be obtained even when the soil surface is not observable (Petropoulos et al., 2015). Although various optical sensors currently in or- bit, studies of soil moisture content retrieval from visible, near infrared (NIR), shortwave infrared (SWIR), and hyperspectral are limited. It is because related with the limited capability of cloud and vegetation penetration, and is highly influenced by the Earth's atmosphere (Petropoulos et al., 2015).

By utilizing thermal and visible, land surface characteristics can be inferred from the remotely sensed data. Land surface temperature can be derived from thermal data. In this case, vegetation canopy temperature can be used as an indicator of vegetation water content that related to the soil moisture content change. Surface temperature indicates soil moisture content of the bare soil surface, soil at the depth of 2 cm, as well as in the root zone. Relation of soil moisture content with satellite derived surface tempera- ture/vegetation index also studied by linking the physical properties of the feature space to the environmental variables (Petropoulos et al., 2015).

Microwave remote sensing has different characteristics with optical/thermal. It has a physically based relationship between the land surface emission and soil moisture. Additionally, the microwave signal is possible to penetrate cloud and vegetation canopy to a certain extent and provide continuous monitoring of surface soil moisture since it is weather-independent. However, there are some limitations for microwave radiometers regardless their advantages. C and X bands microwave radiom- eters are sensitive to soil moisture but it is necessary for data correction regarding at- mosphere condition in these frequencies. In highly dense vegetation area, these wave- length is attenuated by vegetation cover, therefore, cannot effectively acquire soil emis- sion. Meanwhile, microwave operating at L band has higher capability in sensing sur- face characteristics and better penetration, but backscatter acquired is highly influenced by combination of effects of water content, surface roughness, vegetation, topography, and vegetation canopy structure, which obstructs soil moisture retrievals.

Several passive microwave satellite sensors have been utilized to acquire soil mois- ture information at global scale, such as Scanning Multichannel Microwave Radiometer (SMMR), Special Sensor Microwave/Imager SSM/I, Tropical Rainfall Measuring Mission Microwave Imager, Advanced Microwave Scanning Radiom- eter on the Earth Observing System AMSR-E, AMSR-2, Advanced Scatterometer, Soil Moisture and Ocean Salinity satellite, and Moisture Active and Passive. Passive microwave instruments, generally characterised by wide spa- tial coverage and high temporal resolution, but it has coarse spatial resolutions. There- fore, utilisation of certain data is more appropriate for global studies rather than regional scale.

For regional scale, visible and infrared sensors provide a wide range combination of spatial and temporal resolution. It ranges from 10 - 15 meters resolution with 16-day revisit (LANDSAT, ASTER) to 1 km resolution with up to daily observations (MODIS, NOAA). In this case, direct measurement of soil moisture information using visi- ble/ thermal sensor is impractical, and problems of cloud cover exist (Piles et al., 2014).

Therefore, several alternatives to combine and synergize visible/infrared and microwave remote sensing techniques is continuously developed. Numerous attempts have been made to improve the spatial and temporal resolution of soil moisture by disaggregating lower resolution satellite imagery (which generally microwave providing soil moisture information) using higher resolution imagery derived from optical/thermal sensor (Chauhan et al., 2003),(Piles et al., 2011), (Piles et al., 2014), (Merlin et al.,2008), (Merlin et al., 2009), (Merlin et al., 2010), (Zhao and Li, 2013).

Assessing the accuracy and reliability of downscaling products is important. Valida- tion is generally applied to determine whether satellite products agree with the in situ observations (Albergel et al., 2013). Validation results can be used to provide feedback to developers so that the algorithm can be improved. It also enables the potential users to understand the status of the products, besides, can better utilize them for real-world applications (Zeng et al., 2015). Performance metrics to validate geophysical variables derived from satellite measurements can be utilized, such as bias, RMSD, slope of lin- ear regression, and time series correlation (Albergel et al., 2013),(Piles et al., 2014). Regarding downscaling of soil moisture data, results can be assessed by comparing with non-downscaled data at the higher resolution as well as compare them with the in-situ reference data. Evaluation complexity in the soil moisture downscaling method are due to: i) the impact of uncertainties in the input data and ii) measurements of reference data at the validation scale has the possibility of unrepresentative (Merlin et al., 2015).

Numerous dedicated studies have implemented and validated downscaling products of soil moisture using different algorithms. (Jongyoun and Hogue, 2012) compared tri- angle based downscaling method (Chauhan et al., 2003) with UCLA downscaling tech- nique as well as Merlin method (Merlin et al., 2008, Merlin et al., 2009) (early version of DISPATCH) which applied to AMSR-E product. (Sánchez-Ruiz et al., 2014) evalu- ated the performance of the downscaling model similar to (Piles et al., 2014), using water indices (NDWI) as input together with vegetation indices (NDVI) as a compari- son. (Merlin et al., 2015) evaluated DISPATCH using new proposed metric, GDown, to assess the potential gain provided by disaggregation relative to non-disaggregation case.

This study highlights comparison of the developed downscaling methods based on triangle method (Piles et al., 2014) and semi-empirical (physical model) (Merlin et al., 2010, Merlin et al., 2015). Research questions proposed for this research comprise:

1. What are the relative advantages of each product delivered from the downscaling method?
2. Does the downscaling method improve the soil moisture products?
3. Are there any influences from land surface characteristics to the soil moisture estimation from each products?

By answering these questions, the research outcomes expected include:

1. Comparison of downscaled products regarding advantages and limitations of derived products from each method.
2. Evaluation of each method based on derived products using performance metrics
3. Analysis of downscaled imageries regarding certain geophysical variables, such as land use, elevation, slope, and soil texture.

Seasonal and Land Cover Analysis

The seasonal analysis is conducted to identify the performance of soil moisture products related to seasonal variations. Due to the limitation in the number of collocated pairs, analysis seasonal analysis of soil moisture at station scale are not performed. First, all collocated data are divided based on the season. All data from individual station comparisons are clumped and no averaging amongst stations. The study period is divided into four seasons, which are winter (June, July, August), spring (September, October, November), summer (December, January, February), autumn (March, April, May). As acquired data was started in July 2010, which means not coincided with starting of winter, data acquired in June 2011 is combined with 2010 data, based on the assumption that it occurred in the same year. Grouped data then calculated for metrics comparison.

All products obtain approximately similar correlation coeffi- cients in summer. BEC-Aqua obtains R of 0.464 in winter, 0.377 in summer, continued with 0.346, and 0.339 for spring and autumn. Meanwhile, BEC-Terra receives higher R in winter and autumn with R of 0.367 and 0.354 followed by 0.344 and 0.326 for spring and summer respectively. DISPATCH has higher correlation value in spring and summer with 0.265 and 0.331 compared with other seasons. DISPATCH achieve low value in correlation coefficient both winter and autumn, which are 0.202 and 0.099. In this study, result from DISPATCH product is smaller compared with the previously published result (Malbeteau et al., 2016), which ranges from 0.358 to 0.776 for corre- lation coefficient in summer. It is likely that DISPATCH which has the downscaling approach based on evaporation efficiency performs better in summer (Malbeteau et al., 2016)) compared with other seasons, reflected by its R score of 0.331. In this analysis, all R are considered significant as p-value <0.05. For low-resolution soil product, SMOS L3 obtain R ranges from ~0.3461 to 0.4484. Regarding the ubRMSD, most products obtained smallest error in autumn with 0.061, 0.063, 0.096, and 0.063 m^3/m^3 for BEC-Aqua, BEC-Terra, DISPATCH and SMOS L3. It is in line with the expectation that low soil moisture in certain period would impact to low error (Sánchez-Ruiz et al., 2014).

Nevertheless, several conditions may influence the scores. Data of June 2011 were combined with July and August 2010 as one group in winter. Besides that, increasing the number of observations using filling in data pair with the range of day-3, day, and day+3 can reduce the accuracy. Clumping all data without averaging may also limit the score. Other than that, landscape variability (such as variability of rainfall, land use, elevation, and soil texture) may influence the statistical result.

Conclusions

This study aims to compare and validate relative advantages of downscaling products from BEC-Aqua, BEC-Terra, and DISPATCH. Besides that, SMOS L3 is included to investigate further the performance improvement of disaggregated products against coarse resolution data. The satellite products are compared with the in situ measurements of 49 stations distributed within the study area in 1 year period (July 2010 to June 2011). Overall, the disaggregation algorithms (BEC and DISPATCH) are capable of producing better spatial resolution and have a relatively comparable performance to the original input (SMOS) related to soil moisture prediction accuracy.

Based on temporal validation given the threshold of 30 number of observations, there are only 28 stations available. The performance of disaggregated products are relatively comparable with the R ranged from ~0.3 to 0.9 and unbiased RMSD ranged from ~0.02 to 0.1 m^3/m^3 (p-value < 0.05 for the 95% confidence interval). Improvements in R ranged between ~0.02 and 0.14 for BEC-Aqua and BEC-Terra, and ~0.01 to0.10 for DISPATCH against low-resolution SMOS L3 R value.

Although daily and seasonal validation presents less encouraging results, it still rel- atively reflects the performance of each product. Spatial correlation at daily scale with the threshold of 20 observations (concurrent stations), the number of dates is reduced to 40 days. Based on calculations of R, only 0.06 % were significant (p-value < 0.05 for the 95% confidence interval) with range of R ~0.4 to 0.5 for BEC, ~-0.5 to 0.4 for SMOS L3, and none for DISPATCH. As shown in figure 7, the inconsistent pattern of soil moisture between stations (variability of soil moisture among stations) led to the weak correlation between satellite and in situ observed soil moisture. According to the seasonal validation, R from all products are similar in summer with R ~0.3 and unbiased RMSD optimal in autumn with the range of ~0.06 to 0.09 m^3/m^3.

Based on the results, it can be concluded that these downscaling methods improve the SMOS spatial resolution down to 1 km complying the needs of fine-scale regional hydrological applications. To obtain better results, study period of soil moisture product comparisons should be extended, as it can increase the number of observations which increase the possibility of achieving higher significance of results. Future work could also include other algorithms or other satellite platforms.

Analisis Pemanfaatan Tanah di Daerah Pesisir Indonesia Kasus Kota Agung, Provinsi Lampung

Analysis of Land Utilization in Coastal Areas in Indonesia the Case of Kota Agung District, Lampung Province

Nama	: Valentina Ingradiarini
NIP	: 198307292006042001
Instansi	: BPN
Tahun Intake	: 2012
Tingkat Beasiswa	: Master Overseas
Program Studi	: Master's Program Land Management and Land Tenure
Negara Studi	: Jerman
Universitas	: Technische Universitat Munchen

ABSTRAK

Kawasan pesisir merupakan kawasan yang berpotensi memiliki sumber daya alam yang besar. Pesisir kaya akan sumber daya alam, mangrove, terumbu karang dan ikan karang, rumput laut, alga, mamalia laut, pasir dan kerikil, mineral, energi laut. Perbaikan standar hidup dikaitkan dengan bangkitnya pembangunan ekonomi sosial. Perkembangan di perkotaan berkembang pesat harus lebih diperhatikan karena jumlah ruang dalam rangka memenuhi kebutuhan pembangunan itu sendiri secara otomatis penyebaran pembangunan akan melalui daerah pesisir.

Penelitian ini bertujuan untuk menganalisis kesesuaian penggunaan lahan di wilayah pesisir, dalam kasus ini, kasus studi terletak di Kecamatan Kota Agung, kediaman Tanggamus, Propinsi Lampung telah merusak daerah pesisir di tujuh desa pesisir tersebut. Kerusakan pesisir di daerah ini, misalnya, banjir, sedimentasi dan abrasi telah terjadi sejak populasi masyarakat pesisir semakin meningkat. Penelitian metodologi menggunakan analisis berdasarkan aktivitas sosial ekonomi, analisis kesesuaian penggunaan lahan berdasarkan tipologi dan topografi wilayah pesisir dan juga analisis berdasarkan kerangka hukum pemerintah daerah Kabupaten Tanggamus.

Hasil dari analisis tersebut adalah: (1) aktivitas manusia telah berkontribusi dalam hal kerusakan pantai, misalnya pengembangan pemukiman tanpa fasilitas kebersihan sehingga limbah rumah tangga dapat mencemari lingkungan pesisir; (2) perubahan pemanfaatan lahan dari mangrove ke budidaya yang tidak sesuai untuk ekosistem pesisir dan dapat mempengaruhi bahan tanah; (3) pengembangan pemukiman di gudang pesisir (100 meter dari garis pantai telah diklasifikasikan ke dalam kawasan konservasi) tidak diperbolehkan; dan ke depan, Pemda dapat dipertimbangkan kembali mengenai perencanaan penggunaan lahan di wilayah pesisir Kota Agung.

ABSTRACT

Coastal zone is the area which are potentially has a great natural resources. Coastal is rich with the natural resources, mangroves, coral reefs and reef fish, sea grass, algae, marine mammals, sand and gravels, mineral, ocean energy. The improvement of living standard is associated with the rise of social economic development. The development in urban are growth rapidly shall have to be more concerned due to the number of space in order to fulfill the requirement of development itself an automatically the spreading of development will go through coastal area.

This research has a goal to analysis land use suitability in coastal area, in this case, the study case was located on Kota Agung District, Tanggamus residence, Lampung Province have been damaging the coastal area on those seven coastal villages. The coastal damage in this area, for instance, flooding, sedimentation and abrasion have been occurred since the population of coastal community becoming increased. The methodology research are using the analysis based on the social economic activities, analysis of land use suitability based on typology and topography of coastal area and also analysis based on legal framework of local government of Tanggamus Regency.

The result from the those analysis are : (1) the human activities has contributed in term of coastal damage, for instance, development of settlement without cleanliness facilities that the waste of household can be contaminating coastal environment; (2) land use changes from mangrove in to aquaculture that is not appropriate for the coastal ecosystem and it can influence the soil material; (3) development of settlement in coastal shed (100 meter from shoreline has been classified into conservation area) is not allowed; and in the future, Local Government can be reconsidered regarding the land use planning in coastal area of Kota Agung District.

Coastal is the area which are potentially has a great natural resources. In term of it, coastal area offer chance easy accessibility and exploited the coastal natural resources in the land area. In the issue of development country, coastal area has been going to be a space for the development of society growth. The improvement of living standard is associated with the rise of social economic development. The development in urban are growth rapidly shall have to be more concerned due to the number of space in order to fulfill the requirement of development itself. Whether not, the development of cities will be spreading to rural areas that is not supposed to be a developed area, for instance, coastal area. The growth of those aspect will give an impact to the need of land.

The potentiality of natural resources always made this area as a first gate of the development of economic, social and industries. Based on these problem, so there are many human do activities that involved it in coastal zone for example : agriculture, aquaculture, forest industries, infrastructure, mining, national security, petroleum industry, settlements, port and marinas, energy resources etc. Moreover, the condition of degradation of coastal area and the decline in the number of species and productivity threaten coastal communities and human well-being.

Those human usage together with the number of population growth will give an indication of the incline of human need. In order to fullfil the quality of life, people will do any activities. The number of human population and the availability of coastal na resources are not growing simultaneously. Eventhough human do not realize their activities are causing harm because many of coastal ecosystems are concealed. Other times they may have alternate imperatives such as food security, and feel they have no choice but to use both reneable and unrenewable of coastal resources. The changes of coastal ecosystems in term of land use and the number of coastal resources diversity can be not avoided.

The different of interest of each stakeholder are conflicted. There is also separation of jurisdictions and decision-making in term of coastal development. Coastal developers will find the exotic spot area at the land side of the coastal area. Navies address national security interests. Non government organisation and environmental and forestry ministries protect threatened species, coral reefs, wetlands, and mangrove ecosystem. Private company and tourism ministry are trying to develop coastal area which has a big potentiality to attract tourist and for new resorts. Moreover, local communities fullfil their own needs and demands for economic, social, and environmental management have not pay more attention in term of cleanliness of the environment of coastal ecosystem. Between all of this, marine and coastal management has been developed only to achieve certain benefits and with the absently of the awareness at a time. It fails to consider how these multiple each of stakeholder activities and the cumulative result from uses can give affect to the ecosystems.

Human activities in coastal area will give damaged to the coastal ecosystem and environment. The coastal ecosystem is the sensitive area regard to the land use change. Mostly investor are only looking for the profitable and advantages. Those human activities will finally create some built up area that can cause problem in coastal ecosystem. The activities that have been settled in space of coastal area shall be more concerned in term of suitability between the demand or human need and the carrying capacity of coastal ecosystem provide natural resources. Whether not, it will give an impact to social, economy and environment. The problems on coastal area are caused by the exploitation of coastal resources that will give damaged to the environment, for instance, degradation of coastal ecosystems, fish stock reduction and declining water quality from land-based activities have been intensifying the demands on these natural resources, pollution as one of the mainly causes of coastal area damaged and it caused by wasted accumulation of human activities from the upstream to downstream area that have been flowed into the river of watershed and flooding as a result of land use change in the watershed and watercourse area which are ended to ocean. Watershed management authorities focus on freshwater flows.Moreover, the land use change can trigger exploitation. The boundaries of built up area must have to be established. The number of housing and other facilities growth have to be more controlled in term of land use planning system in order to prevent the growth of built up area will be indicated toward to coastal.

In order to achieve the objective of this research, we have to stimulate the case by Based on those research objective above, so we have to find what is the core problem. Related to those objectives so we have to find out :

- What are activities occurred in coastal area ?
- What factors shall be considered in term of development of coastal area?
- How relevant is the land use existing in coastal area of Kota Agung district?
- How is the development of land utilization ?

Based on the frame work as the direction to do research, then the hypothesis shall be presented with the statement below : The uncontrolled growth of built up area can give a contribution in term of land use change and it will give damage to coastal ecosystem.

General View of Tanggamus Regency

Tanggamus Regency is one of residence in Lampung Province which the location is predominantly by coastal area. Semangka Gulf is one of the two big gulfs in Province of Lampung which is located in Tanggamus Residence with length more less 200 km and it is end at two big rivers that are Way Sekampung and Way Semaka. Tanggamus area is influenced by tropical weather more less 28^{o}celsius. Tanggamus residence is bordered with the area which are mentioned below :

- West part adjacent to Residence of West Lampung.
- East part adjacent to Pringsewu Residence
- North part adjacent to Residence of Center Lampung
- South part adjacent to Hindia Ocean.

Topography

Tanggamus residence has variation land of topography area, namely, high land and low land area. Some part of it are covered by hills and mountains more less 40 % and has height 2115 meters above sea level. Low land that covered along coast of Semangka Gulf is downstream area as a part of Way Semangka River which has elevation 0 – 3 % and height 25 -75 meters up sea level. Curve topography which has elevation 8 – 15 % and height 300 - 500 meter is located in Sukoharjo and Panggung Island. Topography's shape from hills until mountains has elevation 25 % and height 500 meters up sea level that is Tanggamus Mountain.

Climate

Tanggamus residence climate is tropical climate with the wind blow from Hindia Ocean. The average velocity of wind ± 5,83 km/hour and it have two direction of wind flow every year, that are from November - March the wind flow from west direction and south west and April - October the wind flow from east and south east. The temperature around 26 - 30 degrees at the height of 20 - 60 meter up sea level and maximum temperature can achieve until 22 celsius. The air humidity around Semangka Gulf ± 80 % - 88 % with precipitation activity between 1750 - 2250 mm.

Oceanography

Tanggamus Residence located at Semangka Gulf has the depth more less 60 meter, but around 15 km from the gulf has the depth more less 200 meter and the depth until 360 m can be found at south west of Semangka Gulf. The intertidal type in Semangka Gulf is mixed intertidal with dominant double type and occurs twice a day and the interval for once another were small. Coast shore of Tanggamus residence also has two different type, first, east seasons (April to September)when wind was blowing toward through the Hindia ocean and the velocity was achieved until 36 cm/s, second, west season (October to March) when the wind was blowing toward through Java Sea with velocity more less 31 cm/s.

General View of Kota Agung District

The case study was taken in Kota Agung District, Tanggamus Residence, Lampung Province. These location has been chosen according to the historical factor that Kota Agung was the important in colonialism era. Kota Agung was chosen as the City of Trade in west pa;rt of Sumatera. It also has potentiality value in term of main center activities of Tanggamus residence. Review of local transportation study of Tanggamus residence indicated the accessibility improvement in west part of Lampung and and development access from ocean. The development of Kota Agung District coastal, especially at the those villages which are spread into 11 villages. It has width area more less 51,89 km². Kota Agung district is a lowland area and it has the height more less ± 59,9 meter from the sea level. It is located on hill of Tanggamus Mountain amid 104 18" - 105 12" of East and 5 05" - 5 12" of South. The total area is 3.356,61 km2 including the area of land and sea. It also one of the Tanggamus Residence's district which has distance :

distance from the city center of Tanggamus : 14 km

distance from the city center of Province : 100 km

Kota Agung is a district and also the city center of local government of Tanggamus Residence. It is located at the valley of the Tanggamus mountain and it also near of Semangka Gulf. Based on the historical, Kota Agung District had been visited by Netherland Colonialism at 1889. There are many tourism place, for example, Terbaya Beach, Marina Beach, Lamuran Waterfall, Sinar Lebak Waterfall, Air Pana Waterfall, Way Kandis Waterfall, City Park, Islamic Center Complex, Semangka Gulf, and Way Lalaan waterfall.

Analysis of Social Economy Activities

The main economy activities in coastal area of Kota Agung District has potential value in agricultural sector, tourism, fisheries, industries. The coastal villages, namely, Baros, Pasar Madang, Negeri Ratu, Kota Batu village has important of economic activity in term of fisheries and aquaculture regarding their topology that are located at coastal area. For instance, Pasar Madang and Baros village has harbor as a place to manage their activity relating to public port, fishes reservoir, sea transportation to other district or places and Tabuhan Island, and market of fisheries as a result of captured from the sailors, so the biggest number of sailors is came from Kota Agung District and gives a big contribution for Tanggamus residence economic.

In 2011 the fisheries production had contributed more less 12,7 million kilogram of fisheries from ocean and land, and 165.100 ton was came from aquaculture sector. It means that Kota Agung district had contributed for more less 11,3 percent in economic sector of Tanggamus residence. Other potential activity is tourism. Kota Agung district has potential tourism sector in term of marine and water sector, for instance, Way Lalaan Waterfall and Kaca Marga Waterfall.. Land use existing along the coastal area of Baros Village, for instance, has been used as tourism function and fisheries.

Social Activities

There are 7 (seven) coastal villages, namely, Kota Batu, Negeri Ratu, Baros, Pasar Madang, Kusa, Terdana, and Kota Agung villages. The length of coastal from those coastal villages is ± 8,075 km (ARC GIS 9.3). The coastal area in Kota Agung has been damaged by climate changes and also from the effect from human activities. There are some places in coastal villages which has problem related to coastal area damaged that are mentioned in this table below : The spreading of coastal community has been moved toward to the beach and some of it has been toward to land. It is caused by some of society livelihood has been changed from sailor to bargainer especially coastal society in Pasar Madang village.

The livelihoods of coastal community in each of coastal villages are different. For instance, the dominant of livelihood in Kota Batu villages are farmers based on the area village covered by aquaculture and plantation. Compare to Pasar Madang and Baros village which has sailors as a dominant livelihood in coastal community and the second place is taken by farmers both farmers of aquaculture and rice field/ paddy and the third place is bargain.

Analysis of Typology of Coastal Area

Typology is a method of classification area based on the characteristics and area quality, environment, land utilization, supplying of facilities based on environment (Public Work Ministry). Coastal area can be vulnerable with flooding because of the land surface at coastal area are lower or similar compare to surface of sea water and it has the elevation between 2 - 15 % (Public Work Ministry, Directorate of Water Resources). Flooding in Kota Batu village as a result from the watercourse of Way Sekampung river that overflow in rainy seasons or in high tides seasons, the water from ocean will be through to aquaculture area in coastal area of Kota Batu village.

According to BAKOSURTANAL (National Mapping and Surveying Coordination Agency of Indonesia) , coastal typology in Indonesia has been determined into 13 type of coastal typology. Relating to Kota Agung district's coastal area, the typology of coastal area are determined into : sandy beach, cultivation forest-ecosystem. This type is potential and productive, so the development of the area in term of value can be more high. Otherwise, these area could be more exploited and the effect could be damaged the coastal ecosystem. Coastal area of Kota Agung district has characteristic as sandy beach. Hills and mountains more less 40 % and has height 2115 meters above sea level. Low land that covered along coast of six coastal villages has an elevation between 2 % - 40 % with the of height 25 -75 meters up sea level.

Based on map above, the typology of three villages have been classified into paddy/rice field, seven villages, namely Kota Batu, Negeri Ratu, Baros, Pasar Madang, Kusa, Terdana and Kota Agung have been classified into coastal and the rest have been classified into plantation. Coastal village has characteristic and potentiality of coastal typology means that the area are influenced by both coastal and land area. The coastal area has high nutrient for plankton and other organism and it also received light. The existence of mangrove and coral reef can be found in some certain area.

Analysis of Topography

According to PUSLITTANAK (2003) , the elevation has been classified into:

1. Elevation between 0-2 %
2. Elevation between 2 - 15 %;
3. Elevation between 15 - 40 % ;
4. Elevation between 40 - 60 %
5. Elevation between 60 - 100 % .

Based on the map below , coastal area of Kota Agung district has topography of aluvial and wavy with the elevation between 2-15%. which means that coastal area of Kota Agung district has been classified into sloping area.

Analyzes of Legal Framework of Coastal Management

There are two area that are the main concerned regarding development of coastal area : (1) Protected Areas; (2) and Cultivation Area. Local Government of Tanggamus has land use planning in Kota Agung District, especially at coastal area of those seven (7) coastal villages.

Land Use Planning in Coastal Area of Kota Agung District

The arrangement of land use planning in Kota Agung District has been developed by local Government of Tanggamus residence and has been determined into development planning 2011 - 2030. There are some issues in regarding coastal management in Kota Agung: Residence period 2011-2030 Kota Agung has been decided into Center of Tanggamus Regency's Activities and capital city of Tanggamus Regency.

Kota Agung has been as a city center which has some function: center of governmental, trade and services, fisheries and (fisheries industries / minapolitan), and industries for Tanggamus regency. Here are some activities :

- Fisheries Catchment Area / Minapolitan
- Aquaculture
- Middle Industries Area
- Household Industries
- Tourism Area
- Rural Settlements Area
- Urban Settlements Area
- Regional Services and Trade Area

According Regulation 27th 2007 regarding the management of coastal area and the small islands In Indonesia and the utilization of cultivation area that mentioned in Regulation number 26/2007 regarding Spatial Planning, the area which has been used for the stakeholder interest in term of economic, social culture and fisheries activities, facilities of liaison and the connection from one island to another, maritime industry, tourism, settlements, and mining. Other activities are including harbor activities, fisheries catchment area and cultivation and tourism, industries and settlement.

Conclusion and Recommendations

Coastal area is the bordered area between land and sea that have been influenced both land ecosystem and coastal ecosystem. Coastal area are rich with natural resources that make human tend to do any social economic activities. Whether there is no more space area in urban are to be developed, the local government will take the rural area as the next space to develop. In these case, coastal are in Kota Agung district.

Local Government of Tanggamus has an idea to develop the coastal area in Kota Agung district in term of economic activities, for instance, fisheries/ "minapolitan", harbor, settlement area, agriculture, etc. However, the development of coastal area area needed land area to be sacrifice. Coastal community, for instance, coastal community in Kota Batu village has changed the land use of mangrove ecosystem into aquaculture of shrimps and "bandeng", or the mangrove area in Baros , Terbaya, Pasar Madang and Kota Agung village has been changed into settlement area and agriculture. The land use change from mangrove into another land cover will give a damage to coastal area itself. Flooding in Kota Batu village, abrasion and sedimentation in Baros and Pasar Madang village are the result from changing land use of mangrove.

According to the analysis of social economic activities, analysis of land suitability based on topography and typology analysis, analysis of legal framework of land use planning of Local Government of Tanggamus Regency, so the result are mentioned below :

Abrasion in Kota Batu, as the result of human activities in term of land use changes from mangrove in aquaculture, agriculture in Kota Agung and Terbaya village, and settlement in Baros and Pasar Madang village;

The settlement area in Baros and Pasar Madang are not equipped by cleaning facilities, for instance, no sewage disposal, so the pollution from household are going through the watercourse which are ended at the ocean. The accumulation of household pollution from settlements will make sedimentation at the seabed and it can cause the addition of sea water surface spreading toward to land and finally at the high tides or rainy seasons the flooding can be not avoided.

Land use change from mangrove into aquaculture of shrimps and "bandeng" fishes as the main livelihood farmers of coastal community. According to the typology and topography analyses, Kota Agung district has seven (7) coastal villages, namely, Kota Batu, Negeri Ratu, Baros, Pasar Madang, Terbaya, Kusa and Kota Agung. Based on topography analyses, coastal area of Kota Agung district has an elevation that are appropriate for certain land use planning of Tanggamus regency. However, and also coastal area of Kota Batu village is vulnerable to flooding.

According to typology and topography analysis and together with the analysis of regulation regarding the development in coastal area, so the development of land utilization in Kota Agung district shall be refer to :

The development of aquaculture in Kota Batu village has to be pay more attention. Regarding the topography analysis, the area are needed the development of artificial vegetation in order to avoid flooding that can cause damage both coastal ecosystem and farmers business. Harbor area as a result of reclamation land are developed in order to support the economic activities in term of fisheries and to increase the fisherman revenue and regional revenue of Kota Agung district. The activities of fisheries that are going to develop are the harbor in Pasar Madang village. Baros village are rich with tourism sector value. The waterfall can move the economic sector in these area.

Based on topography analysis, the area on Baros and Pasar Madang village are suitable for settlement. However, the settlement has to be relocated regarding the location is located within 100 meter from shoreline. The relocated has to be done considering the coastal shed as conservation area in order to keep coastal resources and ecosystem based on President Decree number 32/1990 .

The high and low density of settlement also need revitalization. Sewage disposal, sanitation and other cleaning facilities has to be done by the local government. The revitalization of settlement can avoid the coastal community to live manage and responsible with coastal ecosystem and learn how to keep the sustainability of coastal resources.

The development in coastal area of Kota Agung District shall be considering the coastal ecosystem in Kota Agung District. The recommendation that shall be considering in term of development in the future are :

1. Review the land use planning of Tanggamus Regency regarding the development of aquaculture in Kota Batu village and agriculture in Kota Agung dan Kusa village;
2. Re-forestry of mangrove on coastal area in Kota Agung in order to bring back the coastal ecosystem to avoid the abrasion, sedimentation and flooding;
3. The coastal community settlement shall be provided of healthy facilities, for instance, sewage disposal, sanitation and other facilities related to garbage shelter in order to prevent the pollution from coastal community settlement household;
4. Limited the permission of built up area in coastal area in order to prevent the development of built up area itself go through the shoreline due to the sustainability of coastal ecosystem and conservation area;
5. Land use change in coastal area shall be monitoring and evaluating in the future as a basic of decision making in term of land use planning of local government.

GIS Mobile Untuk Pemantauan Penggunaan Lahan di Glasgow: Implementasi Perangkat Lunak Sumber Terbuka

Mobile GIS for Monitoring Land Use in Glasgow: Implementation of Open Source Software

Nama	: Wahyu Nugroho
NIP	: 198203252009121002
Instansi	: BPN
Tahun Intake	: 2013
Tingkat Beasiswa	: Master Overseas
Program Studi	: MSC Geoinformation Technology and Cartography
Negara Studi	: Britania Raya
Universitas	: University of Glasgow

ABSTRAK

Di era global, perangkat mobile telah banyak digunakan di seluruh dunia. Tingginya permintaan perangkat mobile mendorong orang untuk mengeksplorasi fungsionalitas maksimalnya. Di sisi lain, sistem operasi Android merupakan salah satu perangkat lunak *open source* yang berpotensi untuk dikembangkan karena kelayakannya. Didukung oleh komunitas pengguna *open source,* fungsionalitas *open source* hampir serupa dengan versi enterprise pada level tertentu. *Software open source* menawarkan paket layak yang bisa dikembangkan untuk mendapatkan keuntungan lebih.

Penelitian ini mengambil semua kemungkinan untuk melakukan mobile GIS dengan menggunakan bahan yang layak. Perangkat lunak *open source* adalah persyaratan yang layak yang dapat digunakan untuk tugas tertentu pada GIS. Baik perangkat dan perangkat lunak *open source* diharuskan untuk dinilai. GPS yang disematkan di perangkat dan kinerja daya adalah masalah yang muncul terkait perangkat seluler. Ketepatan GPS yang rendah dan waktu yang terbatas untuk pemakaian baterai telah disorot dalam penelitian sebelumnya. Dengan pertimbangan dengan *open source,* paket QGIS telah dipilih untuk implementasi GIS *mobile* karena mencakup lingkungan klien dan server. Oleh karena itu, versi QGIS Desktop, QGIS Mobile untuk sistem operasi Android, dan QGIS *Cloud server* menjadi fokus utama penelitian ini. Keterbatasan pelaksanaan *mobile* GIS dengan menggunakan paket QGIS telah diteliti untuk menghasilkan prosedur alternatif. Karena *Cloud* QGIS yang gagal mendukung penyuntingan dan pengeditan file, rintangan telah diselesaikan dengan menggunakan penyimpanan *host storage*.

Selanjutnya, pemantauan penggunaan lahan telah dipilih untuk menguji GIS mobile. Area fokus di *Glasgow City,* lapangan kerja dilakukan dengan pertimbangan ketersediaan jaringan seluler. Peta dari proyek Penilaian Penggunaan Darat Skotlandia (HLA) memandu pemilihan lokasi untuk menguji GIS *mobile*. Dengan mencocokkan informasi jenis penggunaan lahan dari definisi HLA dengan kondisi aktual di lokasi, GIS *mobile* diamati untuk diedit.

Dengan itu, penelitian ini berhasil menjawab pertanyaan penelitian yang menyimpulkan pemantauan penggunaan lahan dengan *mobile* GIS dapat dilakukan dengan menggunakan paket QGIS khususnya QGIS *Mobile*. Untuk penelitian selanjutnya, direkomendasikan server *host cloud, open source server,* dan *software database open source* sebagai bahan potensial dalam pengembangan GIS *mobile open source.*

ABSTRACT

In global era, mobile devices have been widely used around the globe. The high demand of the mobile device encourages people to explore its maximum functionality. On the other hand, Android operating system is one of the open source software that is potential to be developed because of its feasibility. Supported by open source user's community, the functionality of open source is almost similar with enterprise version in certain levels. Open source software offers feasible package that can be developed to get more advantages.

This research grabs all possibilities to conduct mobile GIS using feasible materials. Open source software is feasible requirement that can be used for specific task on GIS. Both device and the open source software are required to be assessed. The GPS embedded in the device and power performance are the emerging issues related to the mobile device. The low accuracy of GPS and limited time on discharging battery has been highlighted in previous studies. In consideration with open source, QGIS package has been chosen for mobile GIS implementation because it covers both client and server environment. Therefore, QGIS Desktop version, QGIS Mobile for Android operating system, and QGIS Cloud server are the main focus on this research. The limitation on the implementation of mobile GIS using QGIS package has been investigated for generating alternative procedure. Due to the QGIS Cloud that fails to support file sharing and editing, the obstacle has been solved by employing cloud host storage.

Furthermore, monitoring land use has been chosen for the purpose to test mobile GIS. Focusing area within Glasgow City, the field work was conducted with consideration of cellular network availability. The map from Scotland's Historic Land-use Assessment project (HLA) guided the selection of location for testing mobile GIS. By matching information of land-use type from the HLA definition with actual condition on the location, the mobile GIS was observed for editing.

With that, this study managed to answer the research's questions which concludes monitoring land-use with mobile GIS can be performed by using QGIS package particularly QGIS Mobile. For future research, it is recommended that cloud host server, open source server, and open source database software as potential materials in developing open source mobile GIS.

Monitoring land use has been performed around the globe to retrieve update information and take further decisions. The important role of monitoring land use relies on a good observation method. For several years, remote sensing has been used to retrieve land use information about the earth and has become an indispensible source to maintain updated information. Although relying on the interpretation of remote sensing data is promising but there should be a checking procedure to determine and maintain the accuracy of the result. The proposed process will keep the information on the land use accurate and up to date.

Associated with recording land use is monitoring the environment. In the recent research, Vaughan et al. (2003) and Gouveia et al. (2006) have found that the ability to provide timely identification and warnings of emerging problems has become a major challenge in monitoring the environment. Geographic Information System (GIS) has been used to solve the problems because it is capable of storing, processing, managing, analysing, and displaying spatial and temporal information (Li, 2006).

Furthermore, GIS has expanded into mobile device environment with mobile GIS. Supported by the fast development of information technology, mobile GIS has been widely used in the GIS environment. Tsou (2004) defines the mobile GIS as "an integrated software or hardware framework for the access of geospatial data services through mobile devices via wire-line or wireless networks". Tsou (2004) also has managed to use mobile GIS in the fieldwork to collect and manage environmental data and show that mobile GIS is a powerful device that assists GIS users in various mobile works.

On the other hand, a mobile device with Android Java Programming as language platform has become ubiquitous. Android becomes a potential platform that is maintained by Google as a free of charge open source for users. It allows for anyone to download and build their Android-based application (Holy, 2012).

As implied, the rapid growth of Android programming cannot be overlooked. The challenging part is for mobile GIS software to be installed on an Android mobile device. As solution, a sophisticated user interface is required in Android platform that fits the demands of GIS users. In order to run the software, the Android applications must be written in Java using various Java Application Program Interfaces or APIs.

There are free open source and commercial application programs available for users. The open source applications offer various capabilities similar to the commercials ones, although there are some limitations. However the commercial applications have consumer services that guarantee a full working application and problem handling. In an open source there is an open community that solves any problem from the application.

QGIS Desktop is one example of open source GIS software. It has user interface and tools that are almost similar to the enterprise GIS software. With many interoperability options, QGIS has been developed in a desktop application programs, mobile application programs, and a cloud server for users. The aim of the QGIS projects are for the users to place the map in the server, access and edit their map in desktop or mobile version of QGIS and publish the map on the website.

On the other hand, several types of the mobile device has been embedded with Global Positioning System (GPS). It is possible for the users to apply the device to a particular application in the field survey activities. There is a constraint on accuracy because of GPS capabilities within a tablet device. With this limitation, high accuracy of GPS is needed for a detail positioning in the survey. In this case, the tablet is only utilized for data input before being transmitted to other devices. Land surveying, for instance, needs high accuracy of position and this work cannot be replaced with the built-in GPS on the mobile device (Mensah-Okantey, 2007). However land monitoring is still promising as it contains a checking task with less precision of location required.

In spite of all fears and hopes for GIS on mobile devices, a feasible monitoring land use procedure is desirable. An open source GIS package could be a potential way to perform a fast, efficient, and mobile monitoring land use. The method to be tested enables users to perform land use monitoring using simple internet client and server architecture.

The aim of this projects is broken down as follows; to assess and maximize the utility of mobile devices in field survey especially for monitoring land use using a feasible device and open source software; to analyse online editing, updating, and transfer processes for land use monitoring in a mobile environment; and to implement a test mobile GIS application with its user interface for monitoring land use.

There are three objectives for this project. The first objective is to confirm the mobile GIS works in mobile devices, to ensure the GIS application is fully working and running well on mobile devices, to connect the GPS with navigation sensor within the device, to analyse the GPS accuracy, to connect the device to the server, and to perform map editing, and to display and publish the final result without any significant problem. The second objective is to monitor and compare land use change using open source mobile GIS software on the mobile device. The third objective is to implement document procedures and transfer knowledge to potential users of the system.

Research methodology is divided into three major issues such as; literature review, device assessment, procedures implementation, and experiment. By delivering these topics the research attempts to answer the research questions.

Device Assessment

1. GPS Accuracy

   According to the data of device assessment for GPS-GLONASS enable, a total 307 coordinates had been recorded in one single time. The amounts of coordinates were obtained from continuous recording per 1 second giving total time 5.11 minutes.

From this total numbers, there were 16 different coordinates that represented of repeated coordinates. However, based on guidelines from Federal Geographic Data Committee (1998) the minimum requirement for standard accuracy had been achieved. According to table of calculation in Appendix B, the accuracy of Samsung GT N5120 with GPS-GLONASS enable was 3.4298 metres (95%) with RMSE 2.1267. On the other hand, assessment without GPS-GLONASS had been done as well. Utilizing triangulation calculation of cellular towers to estimate mobile device position, Overall, the GPS-GLONASS enable give better result in accuracy rather than cell tower positioning.

The findings in this research indicated that the accuracy of the device is difficult to measure features in detail. Hence, it is not recommended to use this device for cadastral mapping, otherwise, navigation purpose. In order to enhance accuracy level, the Bluetooth transceiver embedded in the device is able to connect with high accuracy GNSS. However, this device is still appropriate for monitoring land use with given accuracy level.

2. Power Performance

The research was testing the durability of full charging battery in the device. The duration of discharging process in the device represents power performance for maintaining mobile GIS. Based on observation to the device, during full working time and ordinary use, there are maximum and minimum lifetimes of battery to discharge. However, the result could vary with other devices. The condition of battery also affects to performance. Good condition of battery gives maximum performance for device with minimal loss of energy. There are several factors that affect with power performance such as user interaction and background computing. User interaction is more complex to be measured as task from users giving instruction to the device is based on activities. Meanwhile, some applications are still standby even they are not in use. In addition, poor cellular connectivity also made battery to work more and draught immediately.

Power performance on mobile device is significant to support applications. Since the application for mobile is developed, it needs more power to be activated. Improving long last durability of the battery to conduct many applications is the main concern in mobile technology industries. Moreover, mobile GIS needs good power source because many components support the process. Power consumption was considered to design better combination of software. Then several methods can be applied to get an efficient work while performing fieldwork for mobile GIS.

Mobile GIS Implementation

In general, monitoring land use using mobile GIS had been managed using QGIS package. QGIS mobile has been designed to transfer desktop version functionality into

Android device. Therefore, the developer creates graphic user interface (GUI) similar with desktop version. This gives pros and cons since the different ratio of wide screen between mobile handheld and common widescreen of desktop computer. The users of mobile QGIS force to push and touch tiny icons as miniature of desktop version. Without pen drive it will be more difficult for selecting the very small size of icons. Moreover, the position of cursor for digitation and pointing will not be accurate if it performed using relatively big finger. On the other hand QGIS mobile has managed to performed simple editing and open files. GPS positioning that work with the software is very useful for user to perform real time mapping.

Based on experiment using the software, there are performance issues for delivering mobile GIS. In some cases, the software crashed to perform complex tasking. The software cannot handle big files and complex geometry vector files. The first assumption as the answer of this problem is the device architecture and its capacity to handle complex task. As mentioned in the previous chapter, the land use map was successfully opened in both QGIS Desktop and the mobile version after shrinking the area of the map. This evidence was giving consideration in maintaining the map in the QGIS Mobile. Unfortunately this research did not assess size limit of file that can be loaded by QGIS Mobile because of time limitation. In order to monitor a broaden area it is suggested to split the file into small part before deliver to QGIS Mobile. Furthermore, the complexity of geometry structure should be aware, since the original the HLA map was slow to be rendered in QGIS Desktop.

The limitation of QGIS Cloud is on the file editing capability to connect with QGIS Mobile because of WMS limitation. This limitation was considerable to choose cloud storage as connector between GIS analyst and surveyor to synchronize the map. The cloud storage was the last alternative for mobile GIS because the service will only work for a private account and group not for wide scope users. Initialization of Dropbox is unique for private user, it implies only limited client can be covered by this service. There is other option to propose more clients to join mobile GIS system. The cloud host service offers users to adjust level and kinds of application, data, operating system, virtualization, storage and networking. By selecting cloud host that is able to be installed with open source server and database software, file sharing within large users is possible to be performed. The combination between WMS with QGIS Cloud and file sharing with cloud host storage from Dropbox, creates a useful mobile GIS.

The three locations belong to private authorities that difficult to reach. The three types of land use that unreachable are: Restored Agricultural Land, Plantation and Opencast Site. The distances from the nearest main road to the locations were 514.089 metres for Restored Agricultural Land, 406.002 metres from Opencast site and 213.512 metres from The observation planning with dividing the fieldwork into several groups was working effectively. The battery was drain approximately at the end of the surveys. Due to mismatching public transport information between Google Map and local provider, there was a day that battery was run out before the end of survey. The device required more energy to turn on the screen and activate Google Map to get correct route. In order to finish the survey, mobile power source was recruited to charge the device.

Based on the actual observation in 26 sampling locations and comparison study with definition type from the HLA map to identify change, there was no significant change had been found regarded to the definition. The results cannot be taken as evidence for statistical method because the sampling was lack of numbers. Furthermore, the interaction between land use map and real world meet on the field work. The surveyor attempted to figure out the similarities and differences between information on the map with ground reality. In this case, however, the illustration of type based on the handbook and ground truth condition has several differences because of scale factor. The borders between plantation and agriculture planned village, for example, could be misleading and swap. The village itself could not be distinguished because no visual border that can be found on the field. The surveyor needs to be aware with the land use history of the entire area.

Conclusion

Monitoring land use is important for development planning. Information about land use change could be gathered from many resources and various techniques. There are autonomous detection techniques that emerged nowadays. In pursuit to appreciate advance technology and expand land use detection process, it is worth to do monitoring works for ground checking using mobile GIS. This research managed to assess the requirements for mobile GIS using open source software. The questions as the guideline of the objectives in the beginning could be answered in this research. There are some limitations that had been noted:

- The GPS accuracy level of the device is not adequate to perform cadastral survey.
- The power performance of the device is very limited to conduct daylight outdoor surveying.
- A pen drive is very useful in QGIS Mobile for digitizing and selecting small icons.
- The QGIS Cloud is only support WMS file that is restricted for editing. Hence cloud storage such as Dropbox can be used for managing file; however, it is very limited for private and group user.

SPIRIT

Scholarship Program for Strengthening Reforming Institutions

IBRD Loan No. 8010-ID

Bunga Rampai Tesis/Disertasi

Tema:

Geografi

Buku *Bunga Rampai Tesis/Disertasi Program Beasiswa SPIRIT, Tema: Geografi. Kelompok: Ilmu Alam dan Interdisiplin* ini merupakan buku kedelapan dari sembilan buku yang akan diterbitkan pada tahun 2017, sebagai salah satu upaya mendiseminasikan karya tulis ilmiah yang telah diselesaikan oleh karyasiswa penerima beasiswa SPIRIT. Materi tesis/disertasi dibagi menjadi tiga kelompok, yaitu Ilmu-Ilmu Ekonomi, lmu-Ilmu Sosial, dan Ilmu-Ilmu Alam dan Interdisiplin. Dasar pembagiannya adalah disiplin keilmuan (*tree of science*) dan keseimbangan jumlah materi tesis/disertasi yang ada.

Tujuan dari penerbitan serial buku ini, pertama, menyebarluaskan hasil-hasil penelitian tesis/disertasi agar dapat direplikasi atau diadopsi di tempat kerja karyasiswa; kedua, sebagai *benchmark* pemanfaatannya di instansi pemerintah lain; dan ketiga, merupakan bagian dari upaya mendokumentasikan kegiatan SPIRIT, dalam bentuk terbitan ilmiah buku ber-ISBN sehingga dapat disebutkan oleh karyasiswa dalam resume masing-masing. Versi cetak serial buku ini dapat di akses secara *online* www.pusbindiklatren.bappenas.go.id

Serial buku ini diharapkan dapat menggambarkan manfaat dan kontribusi positif Program SPIRIT terhadap peningkatan kapasitas SDM sebagai *participating agencies* baik dari sisi keterampilan teknis, manajerial, dan kepemimpinan aparat pemerintah, dan dalam melaksanakan reformasi birokrasi di instansi masing-masing. Program SPIRIT juga diharapkan dapat berkontribusi bagi pencapaian sasaran prioritas nasional dalam meningkatkan kinerja instansi pemerintah .yang ditandai dengan berkurangnya praktik korupsi, kolusi, dan nepotisme, serta meningkatnya kualitas pelayanan publik.

Kementerian PPN/ Bappenas

The World Bank

ISBN 978-602-1154-94-6

9 786021 154946