Incorporating Land Use Change Analysis and High Conservation Value Area Identification to Assess Possibility of Land Swap and Better Spatial Planning

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Background

Restoration program is not a new initiative to reestablish initial stage of a degraded land. It has been recognized worldwide through Bonn Challenge initiative which aims to restore up to 150 million hectares deforested and degraded land at global level by 2020 and 350 million hectares by 2030 (Bonn Challenge website). When speaking about restoration program, it is not merely about reforesting and tree planting deforested and degraded area aiming for gaining the ecosystem back to its initial stage (Moore et al. 1999), but it also incorporates provisioning back environmental service provided by the ecosystem once it was undegraded (Lindenmayer et al. 2008). As ecosystem is a complex system (Towns 2002) which encompasses many structures, restoration program should be designed as forest landscape restoration (FLR) program in order to gain various advantages over time.

High Conservation Value (HCV) is a concept, firstly developed by Forest Stewardship Council (FSC), to identify forest area permittable for logging activity by excluding forest area with HCV. At the first time it was developed, HCV consisted of only four principles and criteria, which were then further improved by Proforest into six principles and criteria expanding the purpose which was not only limited to forest area, but also any area generally contains HCV (Common Guidance for the Identification of HCV). Thus, the last terminology used is High Conservation Value Area (HCVA). As a landscape level approach, HCVA is in synergy with FLR concept where HCVA identification does not concentrate on small patches area, it emphasis on reciprocal interaction among ecosystem components and landscape dynamics (HCV Toolkit – Indonesia). Environmental services, which are commonly overlooked such as water provision and areas potential to avoid soil erosion, are also taken into account as HCV component, to which this is essential to be included as part of restoration goals. In addition, HCVA concept is also widely used by sustainability initiatives such as Roundtable Sustainable Palm Oil (RSPO), Roundtable on Sustainable Biofuels (RSB), and Renewable Energy Resources Directive (RES-D), hence it makes HCV concept more relevant for various purposes (Smit et al. 2013).

This study applied HCVA concept and land use change analysis across the period of 1990-2015 to select areas potential for restoration program. Potential restoration area selection was based on land swap or land exchange concept, where areas with HCV and experiencing land use change during the study period were considered potential for restoration, while areas with no change and no HCV would become the substitution areas. The study areas covered two provinces in Indonesia, Riau and South Sumatera Province (Figure 1), where deforestation and forest degradation rate was high during 1990 – 2015.

Figure 1. Location of Two Study Areas, Riau and South Sumatera Province

Data

This study used Land Use Map and data issued by Ministry of Environment and Forestry (MoEF) Republic of Indonesia available at Greenpeace website (http://www.greenpeace.org/seasia/id/Global/seasia/Indonesia/Code/Forest-Map/data.html). This Land Use Map spanned the period of 1990 – 2015 and land use data were available at year 1990, 1996, 2000, 2003, 2006, 2009, 2011, 2012, 2013, and 2015 with 22 land use classes:

1. Primary Dry Land Forest (PDLF),
2. Primary Mangrove Forest (PMF),
3. Primary Swamp Forest (PSF),
4. Secondary Dry Land Forest (SDLF),
5. Secondary Mangrove Forest (SMF),
6. Secondary Swamp Forest (SSF),
7. Plantation Forest (*Hutan Tanaman Industri* or HTI),
8. Dry Rice Land (DRL),
9. Dry Rice Land Mixed with Scrub (DRLS),
10. Plantation,
11. Rice Land,
12. Fish Pond,
13. Swamp Scrubland,
14. Swamp,
15. Scrubland,
16. Savanah,
17. Bare Land,
18. Airport,
19. Housing,
20. Mining,
21. Transmigration, and
22. Bodies of Water (BW).

HCV area selection was carry out through spatial analysis from various thematic maps (Table 1). Area selection of each HCV component referred to Indonesia HCV Toolkit – Indonesia and area identification was limited only to HCV 1-4. HCV 2.2 area was not identified because it required field data collection, and HCV 4 only covered HCV 4.1 component due to data availability.

Table 1. Spatial Data for HCV Area Identification

HCV		Source of Data
HCV 1 - Areas with important level of biodiversity	1.1 Areas that Contain or Provide Biodiversity Support Function to Protection or Conservation Areas	Legal Classification Map, Moratorium Land Concession Map, River Map
	1.2 Critically Endangered Species	IUCN Red List Habitat
	1.3 Areas that Contain Habitat for Viable Populations of Endangered, Restricted Range	IUCN Red List Habitat, and Land Use Map (MoEF)
	1.4 Areas that Contain Habitat of Temporary Use by Species or Congregations of Species	RePPProt (Indonesia Land System) Map
HCV 2 - Natural Landscapes and Dynamics	2.1 Large Natural Landscapes with Capacity to Maintain Natural Ecological Processes and Dynamics	Land Use Map
	2.3 Areas that Contain Representative Populations of Most Naturally Occurring Species	IUCN Red List Habitat, and Land Use Map
HCV 3 - Rare or Endangered Ecosystems		RePPProt Map, and Digital Elevation Model SRTM (90 m)
HCV 4 - Environmental Services	4.1 Areas or Ecosystems Important for the Provision of Water and Prevention of Floods for Downstream communities	Peat Area Map (Wetland International), RePPProt Map, Land Use Map

Methodology

All spatial data were processed and analyzed in ArcGIS 10.5. We applied land use change analysis to select areas which experienced land use change and did not experience land use change during the period of 1990-2015. Please note that our analysis only focused on those two points of time, 1990 and 2015. Any change happened in between those two points of time were excluded from the analysis.

HCV 1.1 areas were considered to have importance in maintaining biodiversity of its surrounding areas and were regulated based on law. HCV 1.1 area was generated from policy based thematic maps (Table 1). Areas classified as 'Protected' in Legal Classification Map was taken into account as HCV 1.1 area. Moratorium Land Concession Map or *Peta Indikatif Penundaan Pemberian Izin Baru* (BIPPIP) consisted of areas forbidden for development at present time, because the areas potentially comprised ecological importance not yet confirmed. Under Government of Indonesia Regulation Number 38 Year 2011, 50 meter buffer areas (small river) and 100 meter buffer areas (big rivers) were obligatory for conservation purpose, hence these areas contained HCV 1.1. HCV 1.2 area selection was based on IUCN Red List Species Habitat, while areas with HCV 1.3 were areas of IUCN Red List Species Habitat but limited only to forest area, including Plantation Forest area. Species categorized as Vulnerable (VU), Endangered (EN), and Critically Endangered (CR)

according to IUCN Red List had to be preserved and their viability should be promoted. To simplify the analysis, we opted only key stone species classified as VU, EN, and CR category in Sumatera: Orangutan, Sumatran Tiger, and Sumatran Elephant. Since our study areas did not cover the habitat area of orangutan, our focus of study was only limited to Sumatran Tiger (*Panthera tigris sumatrae*) and Sumatran Elephant (*Elephas maximus sumatrensi*). Indonesia Regional Physical Planning Programme for Transmigration (RePPProt) Map containing information of Indonesia land system was used to generate ecosystems important for temporary use such as bird migration.

Referring to HCV Toolkit – Indonesia, forest intact encompassing area of minimum 20,000 hectare including 3 km buffer areas surrounding it was important to maintain natural processes occur inside the ecosystem, this area was considered to have HCV 2.1. Area selection of HCV 2.3 was quite similar to HCV 1.3 area selection, but area of plantation forest was excluded from the analysis.

HCV 3 areas were identified based on list of ecosystems classified as 'Rare' and 'Endangered' according to HCV Toolkit – Indonesia book. Classification of 'Rare' and 'Endangered' ecosystems were varied across areas with different elevation.

Due to data limitation, under HCV 4 category we only identified areas with HCV 4.1 which were important for water provision and flood prevention. This identification incorporated data of peat areas (Peat Area Map), ecosystems important for water regulation and hydrology (RePPProt Indonesia Landsystem Map), and wetland land use classes (Land Use Map).

As this study aimed to select areas potential for restoration program through land swap mechanism based on land use change analysis, several assumptions were applied:

1. Areas with HCV and experienced land use change during 1990-2015 were taken into account as potential areas for restoration program, because these areas had ecological importance essential to be preserved,
2. Areas with no HCV and experienced no change were considered potential as substitution replacing area number one through land swap mechanism.

Result

Riau Province

Table 2 shows areas with HCV and where land use change took place across the study period in Riau Province. Land use classes listed in the rows were initial land use recorded in 1990, and land use classes listed in the columns were the ultimate land use recorded in 2015. Between those two times of observation, the majority of land use change occurred in Secondary Dry Land Forest (SDLF) and Secondary Swamp Forest (SSF). SDLF mainly changed into Dry Rice Land Mixed with Scrub (DRLS), Plantation, and Forest Plantation (HTI), while SSF massively changed into Plantation, Swamp Scrubland, and HTI.

In proposing restoration program to a selected area, our study emphasized more on large scale agriculture (i.e. Plantation, and HTI) for land exchange mechanism and avoided small holder agriculture (i.e. DRLS) since small scale agriculture commonly belonged to indigenous community. Swamp Scrubland and Bare Land were transitional land uses when land conversion took place, because they normally would not stay for long period before changed into more

permanent type of land use. Thus, we eliminated DRLS and Swamp Scrubland class from further analysis, and only concentrated on areas changed into HTI and Plantation.

If we broke down the area of change (AoC) between 1990 – 2015 into each component of HCV we examined (Figure 2), land use change of SSF to HTI and Plantation comprised a huge HCVA from almost all components, where total area of these two types of change combined encompassed more than one million hectares of HCVA 1.4, HCVA 2.1, HCVA 2.3, and HCVA 4.1. Additionally, it also comprised more than half million hectares of HCVA 1.2, HCVA 1.3, and HCVA 3. Also, it was around 237,423.41 Ha of HCVA 1.1 comprised in the area of change.

In contrast to land use change occurred in SSF, total area of change of SDF to HTI and SDF to Plantation combined encompassed a lot less HCVA compared to SSF total area of change (Figure 3). The biggest HCVA encompassed in the area of change were HCVA 2.3 and HCV 2.1 where these areas covered 505,882.70 Ha and 485,926.73 Ha respectively.

Figure 2. Area of Change of Secondary Swamp Forest into HTI and Plantation During 1990 – 2015 in Riau Province

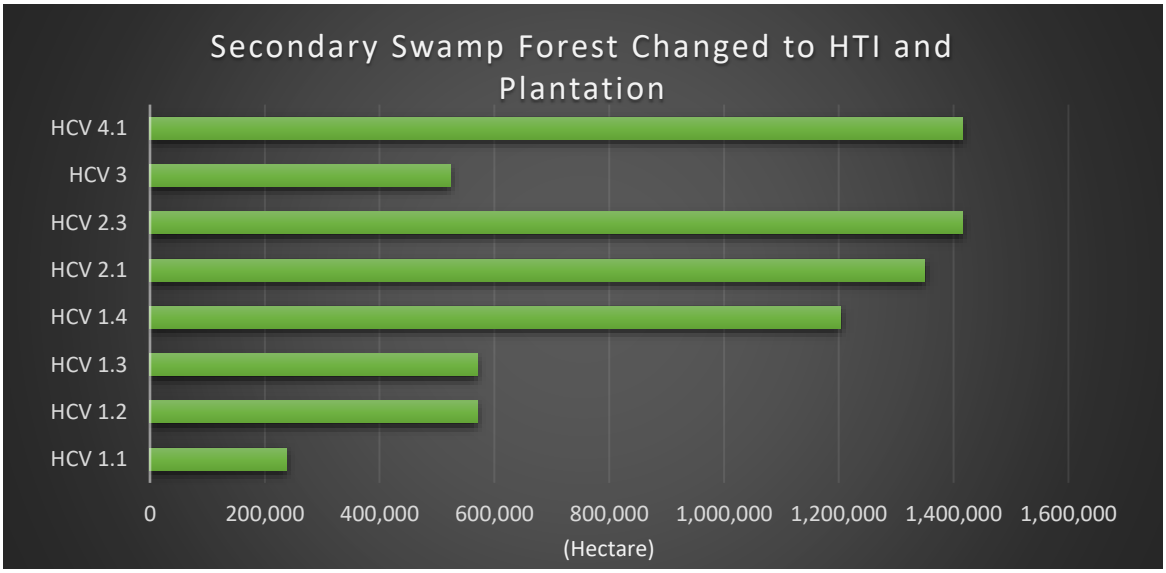


Table 3 shows land use change matrix of areas did not encompass any HCVA. We deliberately excluded areas not potential for land exchange from our analysis, namely: any type of forest class (PDLF, PMF, PSF, SDLF, SSF, and SMF), HTI, Plantation, any type of swamp (Swamp, and Scrubland Swamp), and any permanent land use (Airport, Mining, Housing, and BW). Total area potential for land exchange replacing Plantation and HTI area was 182,826.732 Ha (Table 3), while total area of Plantation and HTI located in all HCVAs was 1,920,840.15 Ha (Table 2).

Table 2. Matrix of Land Use Change (1990 – 2015) in HCV Area, Riau Province (in hectare)

1990/2015	Bare Land	Dry Rice Land	Dry Rice Land Mixed with Scrub	Fish Pond	Forest Plantation (HTI)	Plantation	Rice Land	Savannah	Scrubland	Secondary Dry Land Forest	Secondary Mangrove Forest	Secondary Swamp Forest	Swamp	Swamp Scrubland	Grand Total
Bare Land		3,351.422	4,044.363		1,038.675	20,276.584					3.861			4,656.062	33,370.968
Dry Rice Land	790.613								7.799				308.076	440.479	1,546.966
Dry Rice Land Mixed with Scrub	1,087.621								1,272.775				82.996	391.859	2,835.250
Forest Plantation (HTI)	11,418.091											114.220			11,532.311
Plantation	4,232.474								17.625				0.759	967.610	5,218.468
Primary Dry Land Forest	1,124.197		1,181.485		626.115				578.661	4,594.700					8,105.159
Primary Mangrove Forest	69.782						58.416				3,022.523			57.213	3,207.934
Primary Swamp Forest	19,992.732		1,186.062		21,511.357	20,163.894						53,750.180		18,996.589	135,600.813
Rice Land	1,218.519														1,218.519
Scrubland		9,266.898	174,775.276		16,799.195	78,511.264						104.917		8,440.537	287,898.087
Secondary Dry Land Forest	153,218.534	21,993.103	**387,997.526**		**165,455.346**	**340,427.349**			33,143.250				363.578	11,545.788	**1,114,144.474**
Secondary Mangrove Forest	2,094.078	25.494	1,852.722	1,080.131		3,903.058	611.893						38.264	21,075.749	30,681.389
Secondary Swamp Forest	**431,223.999**	47,307.331	214,903.911		**443,982.284**	**970,975.173**	11,045.781	47.922	1,976.843				882.588	**648,023.155**	**2,770,368.985**
Swamp	22.529					26.192									48.721
Swamp Scrubland	14,943.994	3,087.115	17,317.809		2,092.330	166,661.825	3,046.231		48.265			19,329.721			226,527.291
Grand Total	641,437.162	85,031.363	**803,259.154**	1,080.131	**651,505.302**	**1,600,945.339**	14,762.321	47.922	37,045.217	4,594.700	3,026.385	73,299.037	1,676.260	**714,595.042**	**4,632,305.334**

Figure 3. Area of Change of Secondary Dry Land Forest into HTI and Plantation During 1990 – 2015 in Riau Province

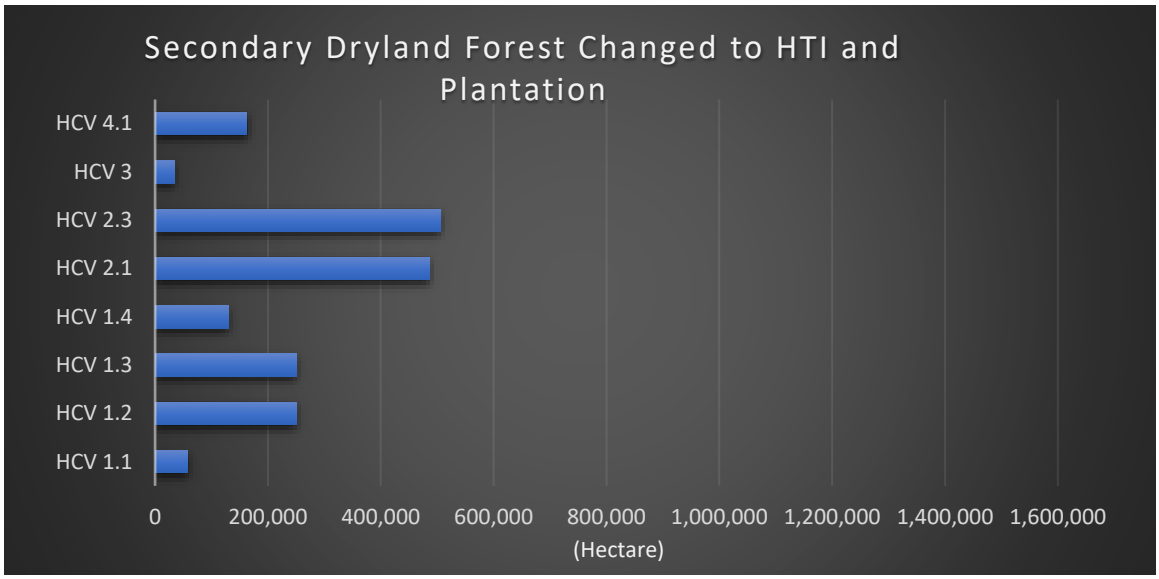


Table 3. Matrix of Land Use Change (1990 – 2015) in Non-HCV Area, Riau Province (in hectare)

1990/2015	Bare Land	Dry Rice Land	Dry Rice Land Mixed with Scrub	Fish Pond	Rice Land	Scrubland	**Grand Total**
Bare Land	**1,657.811**						1,657.811
Dry Rice Land		**45,182.386**	387.163				45,569.548
Dry Rice Land Mixed with Scrub		71.973	**120,222.543**				120,294.516
Fish Pond				**32.296**			32.296
Rice Land		91.685	6.551		**10,931.863**		11,030.099
Scrubland	4,224.383					**18.078**	4,242.461
Grand Total	5,882.194	45,346.044	120,616.256	32.296	10,931.863	18.078	**182,826.732**

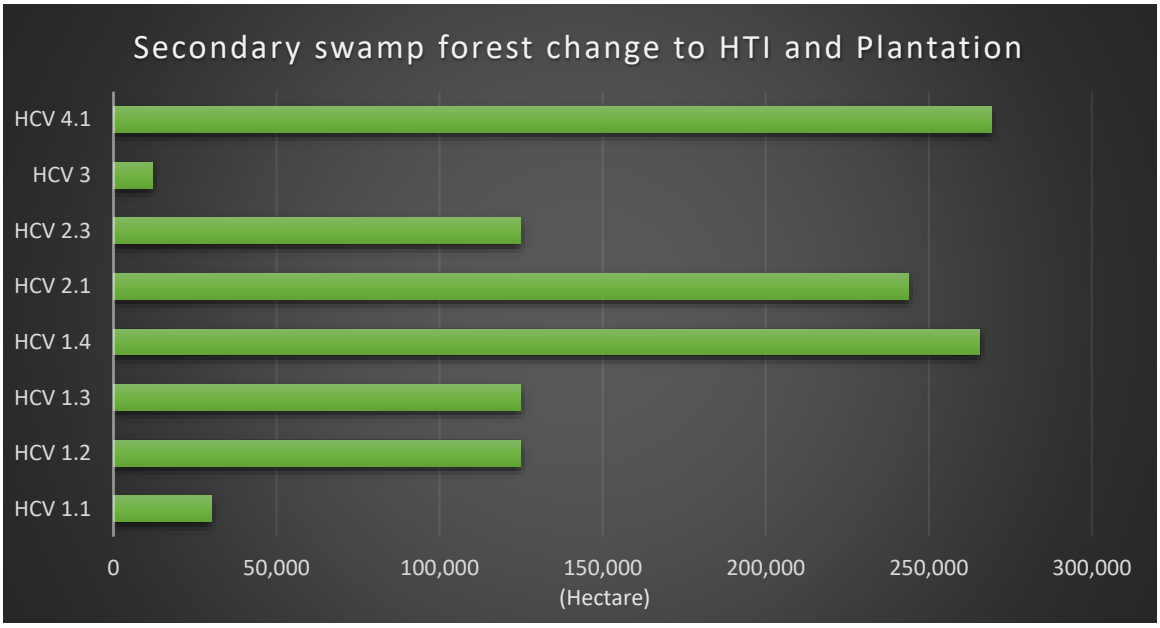
Table 4. Matrix of Land Use Change (1990 – 2015) in HCV Area, South Sumatera Province (in hectare)

1990/2015	Bare Land	Dry Rice Land	Dry Rice Land Mixed with Scrub	Fish Pond	Plantation Forest (HTI)	Plantation	Primary Mangrove Forest	Rice Land	Savannah	Scrubland	Secondary Dry Land Forest	Secondary Mangrove Forest	Secondary Swamp Forest	Swamp	Swamp Scrubland	Grand Total
Bare Land		126.618	479.145		62.745	2,104.220		138.198							1,442.138	4,353.064
Dry Rice Land	206.575								1.994	81.514				100.866	2,036.595	2,427.543
Dry Rice Land Mixed with Scrub	6,274.451								1,288.530	8,222.079				8,190.968	43,768.831	67,744.859
Fish Pond	15.382															15.382
Plantation Forest (HTI)	13,091.529									172.864	593.371					13,857.764
Plantation	1,543.345								221.804						492.501	2,257.649
Primary Dry Land Forest	937.911		1,162.861							2,432.130	9,159.057				23.057	13,715.015
Primary Mangrove Forest	2,521.114			396.864	495.421	475.700		5.396				48,342.905	4,950.515		1,466.745	58,654.660
Primary Swamp Forest	13,881.019		81.327		2,259.962	4,532.444							29.491		1,271.271	22,055.515
Rice Land	30.321														1,119.703	1,150.023
Savannah		57.360	36.210	11.288	1,470.673	3,662.548		2.450							1,555.602	6,796.130
Scrubland		25,384.164	42,027.982	2,961.345	7,383.704	33,325.601		113.290			18,747.298				38,402.948	168,346.331
Secondary Dry Land Forest	**60,474.135**	49,682.358	**117,499.796**		**64,193.813**	**43,649.160**		318.954	2,870.327	73,865.597					620.725	**413,174.865**
Secondary Mangrove Forest	2,011.064			20,652.855	1,183.699	493.057		1,280.353		111.469					4,975.981	30,708.479
Secondary Swamp Forest	**278,309.981**	4,431.589	18,344.299	326.791	**137,260.328**	**136,653.031**	139.821	2,878.618	17,917.824	34,269.398				4,732.062	**179,314.630**	**814,578.373**
Swamp	20,006.303	7,353.130	181.648	1,070.463	78.345	20,255.417		2,054.888	2,192.700	879.307						54,072.201
Swamp Scrubland	**133,352.818**	17,613.086	14,716.490	31,826.821	64,720.338	**226,218.862**		27,310.703	27,033.603	18,330.682		1,343.176	362.915			**562,829.494**
Grand Total	532,655.947	104,648.305	194,529.759	57,246.427	279,109.028	471,370.040	139.821	34,102.850	51,526.781	138,365.040	28,499.725	49,686.081	5,342.921	13,023.896	276,490.727	**2,236,737.348**

South Sumatera Province

Similar to land use change occurred in Riau Province, in South Sumatera Province the major land use change occurred during period 1990 – 2015 took place in SSF, Swamp Scrubland, and SDLF. SSF majorly changed to Bare Land, Swamp Scrubland, HTI, and Plantation, while SDLF mainly changed to Dry Rice Land Mixed with Scrub (DRLS), HTI, Bare Land, and Plantation. As it was mentioned above, any change from and to Swamp Scrubland, Bare Land, and DRLS class were excluded from further analysis.

Figure 4. Area of Change of Secondary Swamp Forest into HTI and Plantation During 1990 – 2015 in South Sumatera Province



If the area of change of SSF to Plantation and SSF to HTI were combined and it was broken down into all HCVA components, this area of change encompassed less HCVAs compared to the area of change in Riau Province. The major HCVAs comprised in the area of change of SSF class were HCVA 4.1, HCVA 1.4, and HCVA 2.1, covering 269,135.08 Ha, 265,588.46 Ha, and 243,772.93 Ha area respectively (Figure 4). It was around 124,712.51 Ha area encompassed the same extent of HCVA 1.2, HCVA 1.3, and HCVA 2.3 equally, while it was less than 50,000 Ha area covered HCVA 3 and HCVA 1.1.

Area of change of SDLF converted to HTI and Plantation comprised relatively small area of any HCV, where it only covered less than 100,000 Ha (Figure 5). It covered the same extent of 79,435.50 Ha of HCVA 1.2, HVCA 1.3, and HCVA 2.3 equally, while 94,994.76 Ha covered HCVA 2.1. It was only small part of this area of change (less than 10,000 Ha) encompassed HCVA 1.1, HCVA 1.4, and HCVA 4.1, and there was no HCVA 3 found in this area.

Figure 5. Area of Change of Secondary Dry Land Forest into HTI and Plantation During 1990 – 2015 in South Sumatera Province

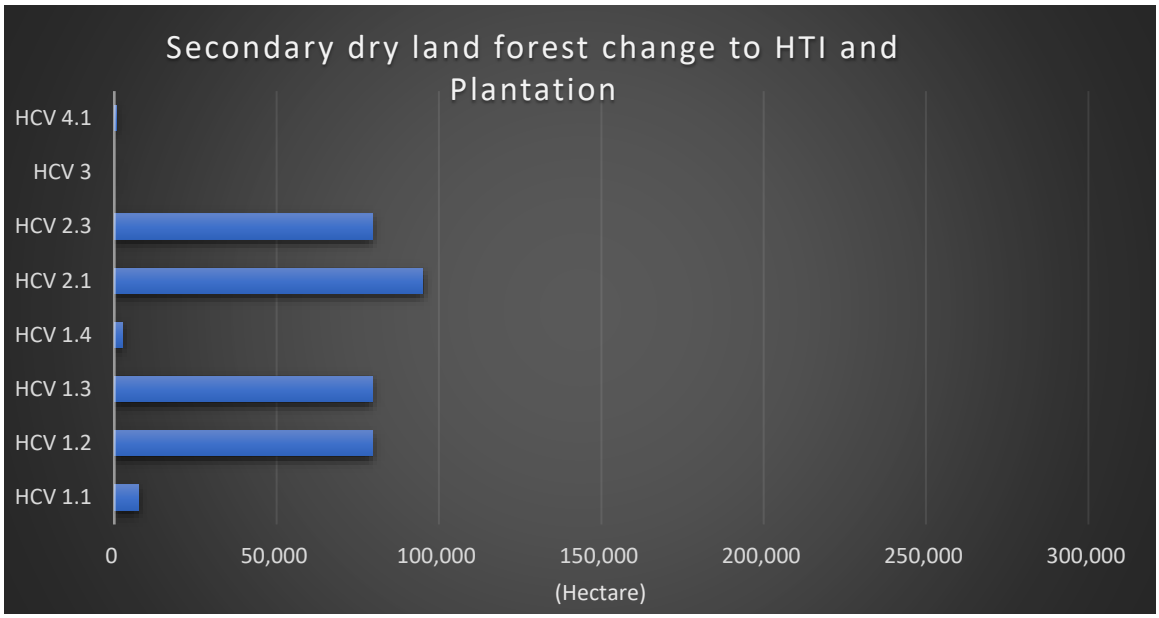
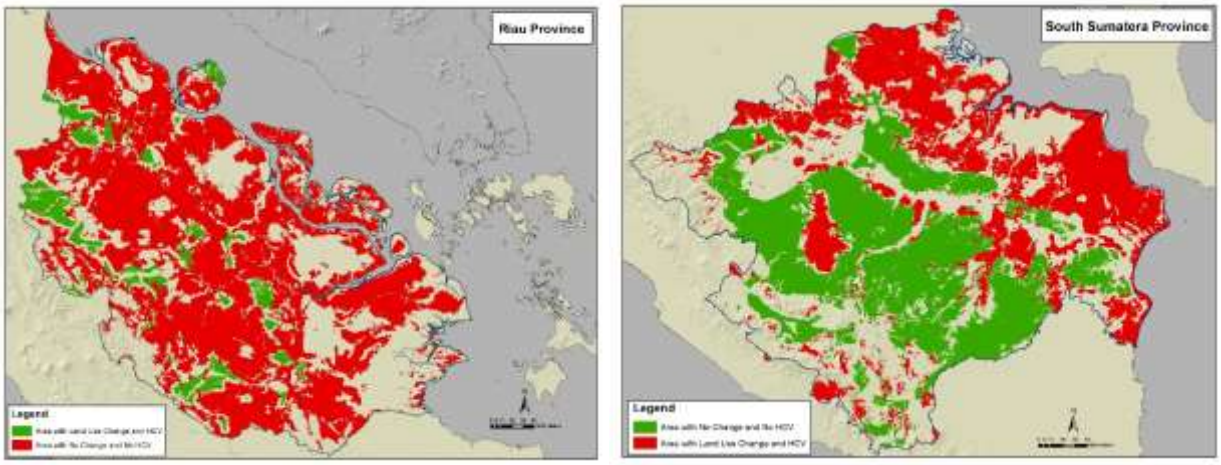


Table 5. Matrix of Land Use Change (1990 – 2015) in Non-HCV Area, South Sumatera Province (in hectare)

1990/2015	Bare Land	Dry Rice Land	Dry Rice Land Mixed w/Scrub	Plantation	Rice Land	Savannah	Scrubland	Grand Total
Bare Land	22,224.235						94.838	22,319.073
Dry Rice Land		187,585.789	7,146.558	11,923.044	17.462			206,672.853
Dry Rice Land Mixed w/Scrub		5,033.764	1,396,761.045	76,067.378	149.135			1,478,011.322
Rice Land			30.421	103.387	146,501.967			146,635.775
Savannah						28,902.139	79.258	28,981.397
Scrubland	5,167.640					508.469	80,978.544	86,654.653
Grand Total	27,391.876	192,619.553	1,403,938.024	88,093.809	146,668.564	29,410.607	81,152.640	**1,969,275.073**

Table 5 shows matrix of land use change of areas containing non-HCVA. Total area potential for land exchange replacing Plantation and HTI area (1,969,275.073 Ha) was much bigger than any HCVA comprising the total area of change from SSF and SDLF to HTI and Plantation all combined.

Figure 6. Areas Potential for Restoration Program (red color) and Substitution Land (green color) in Riau Province (left) and South Sumatera Province (right)



Discussion

When designing a restoration program, landscape analysis is crucial to ensure the success of restoration program (DeFries and Rosenzweig 2010). Analysis of land use change and HCV area identification across the landscape can help to achieve ecological goals we set for our restoration program. However, when speaking of applying land swap mechanism to substitute the area where restoration program is implemented, different areas may give different outcomes due to different conditions in each area. Some areas are highly developed so they left less area for options, while some others are less developed so there are still areas for substitution.

Riau Province is an example of area where massive development took place in the past. During period of 1990-2015, there were 4,632,305.33 Ha area experienced land use change which also encompassed the area of HCV (Table 2). As a result, area left for land substitution in Riau Province is only 182,826.73 Ha. This number is far below the total area of all HCVs that encompassed the area of change of SSF and SDLF to HTI and Plantation combined (1,920,840.15 Ha). If we compare these numbers with the same numbers in South Sumatera Province, in South Sumatera Province the total area of land use change occurred in HCVA was 2,236,737.35 Ha or half of the total area in Riau Province. This has resulted to South Sumatera Province to have more land potential for substitution (1,969,275.07 Ha). This is more than ten times higher than the same number in Riau Province. Thus, it is likely that restoration program through land swap mechanism is more feasible to be implemented in South Sumatera Province than in Riau Province (Figure 6).

In both provinces, area of change in Secondary Swamp Forest contained much larger HCVA (by proportion) compared to area of change in Secondary Dry Land Forest. The biggest proportion of HCVAs comprised in the SSF area were HCVA 1.4, HCVA 2.1, HCVA 2.3, and HCVA 4.1. This is logical because HCV 1.4 emphasis on suitable habitat for temporary use, in Indonesia case it commonly refers to wetland ecosystem, which provides temporary shelter for migrating birds and place for water species to spawn and lay their eggs. Wetland ecosystem is also essential for water

provision and flood prevention because it regulates water and maintains hydrology function, hence it highly contains HCV 4.1. The area of change in Secondary Swamp Forest and in Secondary Dry Land Forest mutually covered areas of HCV 2.1 and HCV 2.3, this is because the two types of forest provide a big core continuous forest area to maintain all natural processes and dynamics in it. These forest areas also provide viable habitat for wildlife to live, in which these are two main factors taken into account in HCV 2.1 and HCV 2.3.

The consequences of HCV 1.4 and HCV 4.1 area loss among others is degradation of hydrological function in the respective watershed, and this leads to flood, declining water supply, and population loss of water species. Reduction of HCVA 2.1 and HCV 2.3 can lead to wildlife extinction, disruption of ecosystem equilibrium which will cause domination of a certain species, and human-wildlife conflict due to habitat loss.

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Arief Wijaya

Brief Biography (100 words):

Zuraidah is working at WRI-Indonesia as Forest and Climate Research Analyst. Her responsibility is to conduct research on issues related to Indonesia climate, forest, and land use, as well as to work on spatial data and analysis. Prior to joining WRI Indonesia she was involved in several forest, land use, and climate related projects. She has expertise in conducting analysis of land use and land cover change and trajectory (ALUCT) in relation to hydrological assessment, above ground carbon stock, and biodiversity. She is also experienced in high conservation value area identification as part of land suitability assessment for oil palm.