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Deforestation Profile of Regency Level in Sumatra

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Abstract

Sumatera Islands is an island with the highest deforestation rate in Indonesia for the of period 1990–2010, even in Southeast Asia. Deforestation assessment based solely on value of deforestation rate. Deforestation rate was not able to be explained and distinguished at areas that still covering a lot of forest, even at areas that less or no forest. The lowest rate results or zero (0) will be significantly better or assessed as undeforested area. This study was developing profile deforestation at regency level. Main objective of this study was to develop a new formula describing the profile of deforestation at regency level in Sumatera Islands, for the 1990–2013 period. The deforestation profile was analized on the annual rate of deforestation and analysis of deforestation profile. The results showed that profile of deforestation occurred in 152 regencies/cities in Sumatera Islands in each regency in period of 1990 to 2013 is the highest profile of Small-Early-Low deforestation (48 regencies/cities) and profile Small-Lately-High deforestation (34 regencies/cities). The study also indicates that the incidence of deforestation in Sumatera Islands (regencies/cities and provinces level) have mainly been occurred in early period (1990 to 2000).

Keywords: Profile of deforestation; rate of deforestation; deforestation proportion; Sumatra Island.

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1. Introduction

Changes in forest cover in tropics area become major topics related to world carbon trading [1-4] and its impact on climate change. The impact of climate change could affect human life and other living components such as accumulation of greenhouse gases in the atmosphere [5, 6]. The role of sustainable forest becomes important in the context of keeping global climate, carbon storage, hydrological processes and biodiversity [5, 7-8]. Changes in forest cover as focus of attention are changes in forest cover or other non-forest (deforestation) [9-10]. Deforestation has become a global environmental issues, in addition to issues of land degradation, biodiversity, food security and environmental sustainability [11-12]. Expansion of deforestation, especially in tropical region caused a decline in environmental quality. Another effect is global climate change, declining quality of habitat, and extinction of species [13].

Deforestation is a forest cover change into non-forest area or region to other use permanently. However, term of deforestation is still debatable [14]. FAO states that deforestation is conversion of forest to other land use. Deforestation is also interpreted as a reduction of tree canopy cover to less than minimum threshold of 10% for a long term with a minimum tree height of 5 meters at minimum area of 0.5 ha [15]. Deforestation in this study is defined as forest cover (land cover) causing changes in form of permanent lost cover at both forest cover intact, fragmented and scattered.

Deforestation causes forest degradation. Forest degradation is defined as forest changes that negatively affect stands or footprints [16]. Degradation lowers species composition, biodiversity, and forest productivity [17]. Forest degradation becomes a global issue because of its significant contribution to global climate change. Land degradation will lead to a decline of land productivity in future [18]. Land degradation causes poverty in and around forests. It also accelerates forest destruction [19]. Forest degradation is also an important process in landscape fragmentation [20].

Deforestation leads fragmented forests [21]. Significantly, it has an impact on increasing fragmentation [22-23]. Forest fragmentation results increased isolation of forest patches associated with quantitative measures of fragmentation. Separate parts of forest in a landscape dominated by human life with less than one hectare width [24]. Forest clearance and forest conversion continued by variety of other uses have separated forests compactness. At certain locations, concentrated forest is still founded [25]. This large forest is usually converted into agricultural land [26]. Land clearing and forest conversion lead to fragmentation of forest landscape. These activities have also led to destruction of forest biota and loss of suitable habitat for sensitive species [27]. It also increases competition of common species [28] and genetic isolation of sub-populations [29]. Fragmentation is also one of main factors triggering loss of forest landscape biodiversity [30]. On the other hand, fragmentation is a threat of biodiversity loss [31] for some species.

Deforestation causes rising temperature, even change of seasons cycle. As a result, it increases frequent of forest fires and rising sea levels. In fact, forest fire in Indonesia continues to occur yearly. Very large of forest fire occurred in 1982; It amounted to 3.2 million hectares. Furthermore, it also happened in 1994 at an area of 9.765 million hectares [32]. Deforestation also trigger land degradation at Sumatra island. One example of forest

degradation occurred in North Sumatra, which reached 2.4 million hectares of critical land [33]. Other relevant studies reveal that deforestation in tropical forest and deforestation also occurred in 1990. It caused greenhouse gas emissions by 17% [34]. Emissions of greenhouse gases increase the earth's temperature recently and it is believed to have raised worldwide [35-36].

Based on various deforestation impact, it is necessary to increase indicators for environmental change [37]. Moreover, environmental indicators need to be developed such as deforestation assessment indicators. Factually, deforestation has been assessed based on deforested area and are measured at present time over the world[38]; Similarly, it is also studied of deforestation in Indonesia and extensive research on the rate of deforestation has been done, especially in Sumatra island. Among these studies is FAO study which states that forest resources are deforested by 1.7% in period of 1990 to 2000 [17]. FAO also showed that deforestation tends to decline 0.5% from 2000 to 2010. Deforestation in Indonesia covered an area of 15.15 million hectares in 2009 [39]. It is still higher than deforestation rate of Southeast Asia countries that just reached 1% in period of 1990 to 2000. In fact, deforestation in Southeast Asia is only 0.4% from 2000 to 2010 [17].

Sumatra Islands is an island with the highest deforestation rate in Indonesia. It is estimated at 6.5 million ha (28%) in Sumatra island during the period of 1985 to 1997 [32]. The island has lost 7.54 million hectares of forest cover in the year of 1990 to 2010 [40]. More detail, deforestation in Sumatra island in period of 2000-2006 is about 292,029.2 hectares per year. Furthermore, the deforestation dropped dramatically to about 72,905.3 hectares per year in period of 2006 to 2012 [41]. The highest loss of forests happened at Riau Province that is by 42 % from 1990 to 2010. Existing forests in Sumatra have been destroyed about 70% in period of 1990 to 2010 [40].

Assessment and research of deforestation has always focused on rate number and extensive deforestation [38]. Rate indicator and area of deforestation have been widely used for monitoring deforestation [32, 39-41]. Low deforestation rate value is always interpreted as a low deforestation in certain periods. In fact, in certain circumstances, the value of low rates of deforestation caused by low initial forest area remaining in a period of observation. Low rate value of deforestation can also be caused by condition of forests that have been depleted. As a result, assessment of deforestation has relatively been incorrect. Assessment is based on calculation of deforestation rate. It is only less able to explain deforestation process. Low rate is always interpreted as a lack of deforested areas. This low rate is also interpreted as well preserved forests. High rate is always interpreted as an area that has experienced of high forest destruction.

Limitations of information based on calculation of deforestation rate has been evaluated in several studies. First evaluation form that used curvature matrix proportion and rate of deforestation is called curvature profile deforestation [38]. The study focused on proportion of rate value as a leading indicator. In detail, the study is intended to preparation of conservation strategies. The second form is a form of evaluation research that build profiles for variables of land use categories [54]. Unfortunately, some of these studies have not assessed roles of forest area yet. In contrary, these roles is necessary to describe process of deforestation earlier. So that, information obtained just about wide, pace, and period of deforestation. This information is used until this time to describe deforestation area within a country.

Research on deforestation profile is conducted to find a new formulation of deforestation assessment. Attention on deforestation profile is about the importance of forest area in early observations. In addition, this study analyzes meaning of value of deforestation rate. Initial forest area and amount of deforestation define and describe of deforestation process in certain periods. Deforestation profile research was conducted to find other valuation techniques to complete deforestation assessment within an observation period. Deforestation profile is defined as an occurrence of deforestation information. Moreover, deforestation profile is a combination of initial forest area (small/large), level of deforestation value on beginning or ending at observation period (early/lately deforestation), value of deforestation rate at beginning or ending (low/high deforestation). Additionally, other combinations are profile areas without deforestation and forest areas. Research unit is all regencies/cities in Sumatra Islands. Main objective of this study is to formulate regency-based deforestation profile as an alternative to deforestation assessment in Sumatra Islands.

2. Materials and Methods

2.*1. Research sites*

This study was conducted in Sumatra Islands. Sumatra archipelago includes the islands of Sumatra and small islands in vicinity. Sumatra islands located from east longitude 950 to 109.20 east longitude and north latitude 60 to 6,20 South latitude (Figure 1). Sumatra islands are divided into 10 provinces and consists of 152 regencies/cities. Width of Sumatra Islands is 47,693,691.34 hectares.

Sumatra islands are choosen as research area because of high rates of deforestation. Sumatra Islands are also the largest of three islands that suffered from deforestation in Indonesia [41]. Sumatran forest conversion into non-forest area has attracted national and international researchers [40-44].

2.2. Data

This study uses land cover data from the Ministry of Forestry of Indonesia in 1990, 1996, 2000, 2006, 2011 and 2013. The usage of land changing data historically can improve accuracy of image classification [45]. Administrative map is released by the Geospatial Information Agency (BIG) of Indonesia in 2010.

2.3. Research stages

2.3.1. Size analysis and distribution rate of deforestation

Extensive analysis of deforestation was initiated by the Ministry of Forestry. It consists of 23 classes covers [46]. Six classes covers are primary forest, secondary forest, primary swamp forests, secondary swamp forest, primary mangrove forests and secondary mangrove forest. All classes cover are merged into the forest. Forest plantations are excluded from group itself because it is assumed that there is no permanent change cover. Other covers (18 land covers) were merged into non-forest class cover [1, 47].

The class cover is overlaid with administrative boundaries maps of Sumatra Islands which regency based.

Overlay result is used for deforestation analysis. Deforestation is defined as land cover changes of forest cover permanently. Deforestation is divided into several observation periods: 1990-1996, 1996-2000, 2000-2006, 2006-2011, 2011-2013 and 1990-2013.

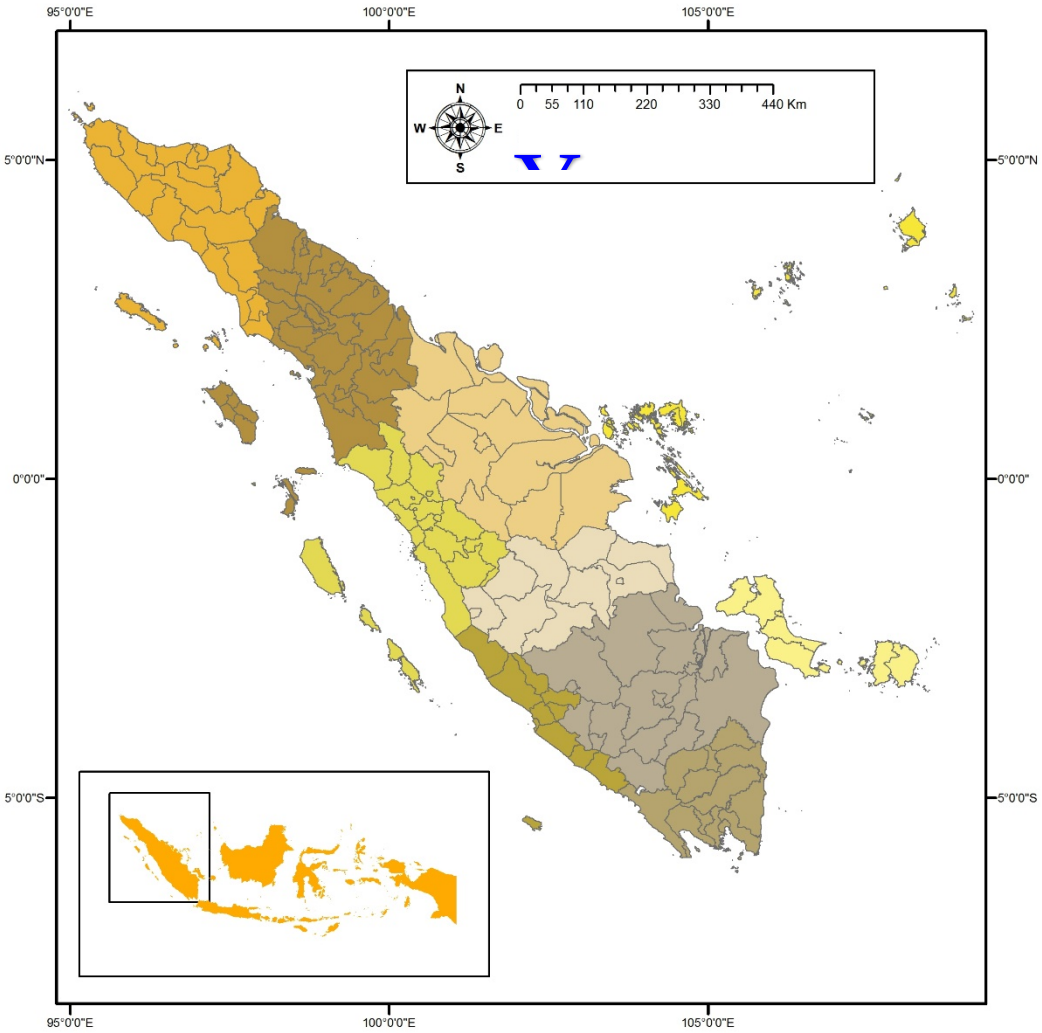

Figure 1: map of research location

Monitoring of deforestation requires detail calculation on deforestation rate [38]. Analysis was conducted to determine deforestation rate in each regency in Sumatra Islands. Analysis of deforestation carried out at all observation periods. Annual deforestation rate is calculated by equation of annual forest cover change. It is derived from law of compound interest [38, 48-53]. Annual deforestation rate (r) is recommended because it is more intuitive than previous formula used by FAO (q) [52]. R value is always higher than q. In many cases, difference in the two formulas is lower than it of sampling error. Rate of forest cover change yearly (r,%/year) is calculated based on forest cover initial (A1, ha) in early period (t1, year) and extensive forest cover end (A2, ha) in final period (t2, year). It is formulated as follows [52]:

$$r = \left(\frac{1}{(t_2 - t_1)}\right) \times \ln\left(\frac{A_2}{A_1}\right) \qquad (1)$$

Extent and rate of deforestation during observation periods in each regency is analyzed descriptively. Changes and trends in spatial of deforestation during observation periods provide information about incidence trend of deforestation in Sumatra.

2.3.2. Analysis of deforestation profile

Analysis on deforestation profile is conducted to identify other variables that affect deforestation. Identification of aspects that reveal history and events of deforestation has been investigated by Ferraz *et al*. [38]. The study shows that trend of deforestation is based on a quantitative approach. This approach differs from Hietel *et al* approach. It creates a profile of variables on land use categories [54]. Analysis on deforestation profile was conducted with respect to the importance of forest area. Initial of forest area determines process of deforestation in certain periods. Deforestation profile is defined as a combination of forest area initial owned by a region with deforestation events (early/lately) and deforestation (low/high). Low initial forest is categorized as Small Deforestation while broadly initial forest is categorized as Large Deforestation. High deforestation rate in early period of deforestation is categorized as early deforestation. High deforestation rate at the end of period is considered as final deforestation (late deforestation). High deforestation rate in first period of deforestastion is categorized as Low deforestation; High deforestation rate at the end of period is classified as High deforestation [38]. Combination of early forest area, the incidence of deforestation has 10 deforestation profiles. Regencies that have no forests are also classified as Forest Area without profile. Categorization on deforestation profile modifies scenario of land use history [38].

Further analysis is an analysis of proportion on forest area starting by deforestation. This analysis is conducted to add information about deforestation based on proportion of deforestation by initial forest area. Early forest area becomes an important factor because it affects scale and incidence of deforestation in certain periods. Proportion among deforestation of initial forest area will show better information than information based on rate of deforestation solely.

3. Results and Discussion

3.1. Forest extensive, rate and distribution of deforestation at regency level in Sumatra Islands

Sumatra islands have forest area of 21,185,442.52 hectares in 1990. Forest area on year of 2013 remained 12,324,316.79 (58.17%). Some research in Sumatra, which is in line with results of this study, have demonstrated scale of lost forest area for over 20 years. Furthermore, forest area in Sumatra in 2000 amounted to 15.69 million hectares which then declined to 13.58 million hectares in 2010 [40]. Moreover, Sumatra forest area in 2008 amounted to 21.9641 million hectares and then declined to 11.27005 million hectares in 2012 [55]. Finally, forest cover in 2011 amounted to 14.84 million hectares [56] and then declined to 13.97 million ha in 2012 [57].

Based on land cover analysis and deforestation analysis, the widest forest area in early observations (1990) is in Pelalawan Regency, Riau Province. At that time, forest area in Pelalawan covered 982,011.20 hectares. Lastly, remaining forest area in Pelalawan was 337,737.56 ha (34.39%) by end of observation (2013). The highest rate

of forest area at provincial level in 1990 was 5,657,461.03 hectares at Riau Province. In detail, Riau Province remained forest area of 1,799,956.22 hectares (31.82%) in 2013. Nanggroe Aceh Darussalam (NAD) Province had the second highest of forest area in 1990, which was 3,753,162.33 hectares. Furthermore, NAD remained forest area of 3,188,207.15 hectares (84.95%) in 2013. Jambi Province had the third highest forest area in 1990, which is 1,208,469.85 hectares. In detail, Jambi forest had 1,208,469.85 hectares (43.14%) in 2013. The narrowest forest area in 1990 was located at Riau Island Province (Kepri), which is 320,005.66 hectares. Kepri remained forest area of 267,918.31 hectares (83.72%) in 2013 in detail(Figure 2).

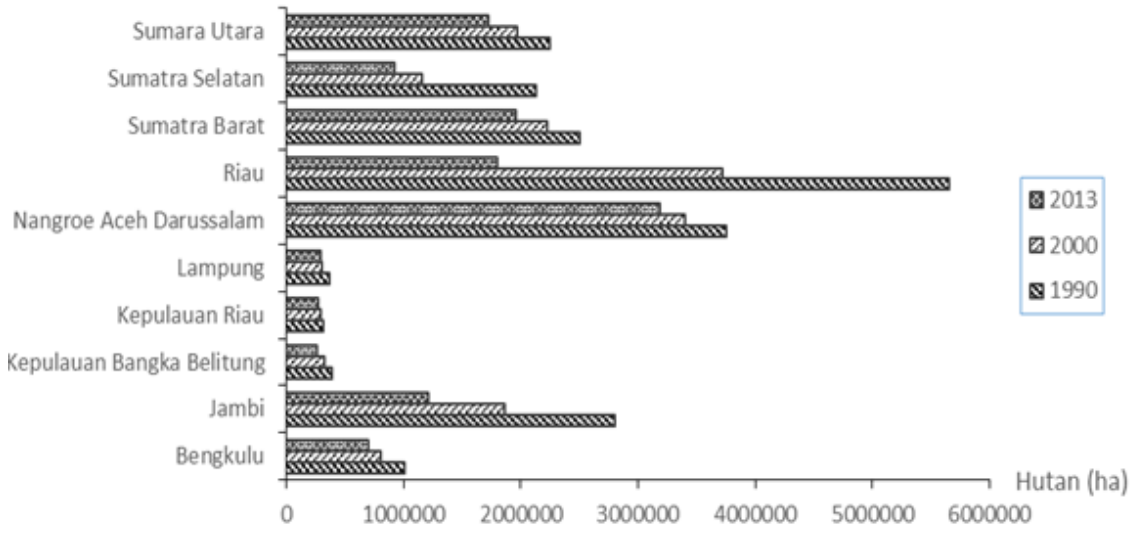

Figure 2: initial forest area by provinces in Sumatra Islands

Based on analysis of forest cover in each regency/city in Sumatra Islands, it was found that there were 12 regencies/cities (7.89%) with no forest. Twelve regencies/cities had no forest since 1990. The regency/city were Jambi (Jambi Province), City Metro (Lampung Province), Banda Aceh (Nanggroe Aceh Darussalam Province), Bukit Tinggi and Pariaman City (West Sumatra Province), Lubuk Linggau and Prabu Mulih City (South Sumatra Province), Binjai, Gunung Sitoli, Pematangsiantar, WPNK-Su and High Cliff (North Sumatra Province).

Extensive deforestation in Sumatra Islands from 1990 to 2013 occurred in Rokan Hilir Regency, Riau Province. The Rokan Hilir Regency had deforested about 464,559.85 hectares or an average of 20,198.25 hectares per year. Precisely, Rokan Hilir deforestation rate was 31.79%. Even, extensive deforestation in five regencies/largest city in Sumatra was occurred all in Riau Province. The five regencies were namely Rokan Hilir, Pelalawan, Indragiri Hilir, Kampar and Bengkalis. The smallest deforestation was occurred in Payakumbuh Regency, West Sumatra Province, that was amounted of 5.53 hectares. Payakumbuh forest area in 1990 was 321.83 hectares. Deforestation in Payakumbuh occurred in period of 2006-2011. In addition, there were five regencies/cities (3.29%) with no deforestation. The five regency/city were Bandar Lampung, Palembang, Base Pinang, Samosir and Solok.

Highest deforestation rate in period of 1990-2013 was 81.72%. It occurred at Mesuji Regency, Lampung

Province. Furtherly, second highest rate of deforestation was 57.56%. It occurred at South Labuhan Batu Regency, North Sumatra Province. The third highest rate of deforestation was Pekanbaru City, Riau Province. It amounted to 48.76%. Mesuji Regency suffered the highest deforestation in period 1996-2000 (11547.18 hectares). Deforestation in South Labuhan Batu largest occurred from 1996 to 2000 covering an area of 26197.92 hectares. Meanwhile, the largest forest loss was happened at Pekanbaru city from 1990 to 1996 (6137.58 hectares). In contrary, the lowest rate of deforestation occured at Padang Pariaman (West Sumatra Province, 0.06%), North Lampung Regency (Lampung Province, 0.09%) and South Lampung Regency (Lampung Province, 0.13%). The highest rate of deforestation in Sumatra Islands showed that deforestation occurred at beginning of observation period, from 1990 to 2000. The rate of deforestation was highest in Riau Province [41]. Conversion of forest areas into non-forest areas in Indonesia mainly due to forest conversion to oil palm plantations [58]. Conversion of forest into plantations was conducted by large companies. Other factor, forest conversion due to community encroachment [44].

Massive forest area conversion and deforestation are generally interconnected. High conversion of forest area was likely to encourage high deforestation. High deforestation in Sumatra occurred mainly in areas that have large areas of forest. This condition was found at regencies of Pelalawan, Indragiri Hilir, Kampar, Kuantin Singingi, Rokan Hilir, Siak, Ogan Ogan Ilir and Tebo. In addition, deforestation also happened at regencies with high forest cover and low deforestation such as in Mentawai Islands, Meranti Islands, Kerinci and Batam. Furthermore, there are also several regencies with small forest area but they had high deforestation i.e. at the regencies of Langsa, Lhokseumawe, Dumai and Sibolga. However, there was also regencies/cities in Sumatra without deforestation. Deforestation did not happen due to two factors. Firstly, regencies/cities are able to maintain and protect forests from activities that cause deforestation. Secondly, regency/city does not have forest area. Forest areas that have been depleted was caused by deforestation in period prior to the observation (before 1990).

Calculations based on rate of deforestation can only lead to mis-information [32, 39-41, 55-58]. As a result, meaning of information about forests condition of a region or country has potential to provide incorrect information. Low (or zero) of deforestation has generally been taken to mean that the regency/city is not deforested. In general, low deforestation value was assumed as better area than area with high deforestation. Moreover, high deforestation rate value is defined as massive damaged forest area. Usually, low rate value is defined as under control forest area. It brings to broad error meaning to the values and rate of deforestation generally. Ironically, these assessments take place both at regency level and province level in Indonesia, even in the world. Similarly, this condition also occured on assessment of forest damage level in Sumatra [39-41, 56-58]. This study found 17 regencies/cities in Sumatra, which were not deforested. The regencies/cities had zero deforestation rate over period of 1990-2013. Results of this study also proved that the 17 regencies/cities were not experiencing different deforestation. The difference lied in the existence of early forest and ability to keep the forest from deforestation. There were 12 regencies/cities that did not have forest area since the beginning of observation period (1990). In addition, there are five regencies/cities were able to keep remaining forests against deforestation.

Result of spatial distribution analysis on deforestation shows distribution maps of deforestation occurred from

1990 to 2013 (Figure 3). Deforestation had occurred from 1990 to 1996, especially in provinces of Riau, Jambi, North Sumatra and West Sumatra. In second period, from 1996 to 2000, deforestation was widespread and scattered across Sumatra Province. Deforestation changed distribution and tended to gather in several provinces in third period (2000-2006). Moreover, distribution of this deforestation happened in provinces of Riau, Jambi, West Sumatra and North Sumatra. Lastly, in period of 2006 to 2011, wider distribution of deforestation occured from east to south, especially in provinces of South Sumatra, West Sumatra, Jambi, Riau and Riau Islands.

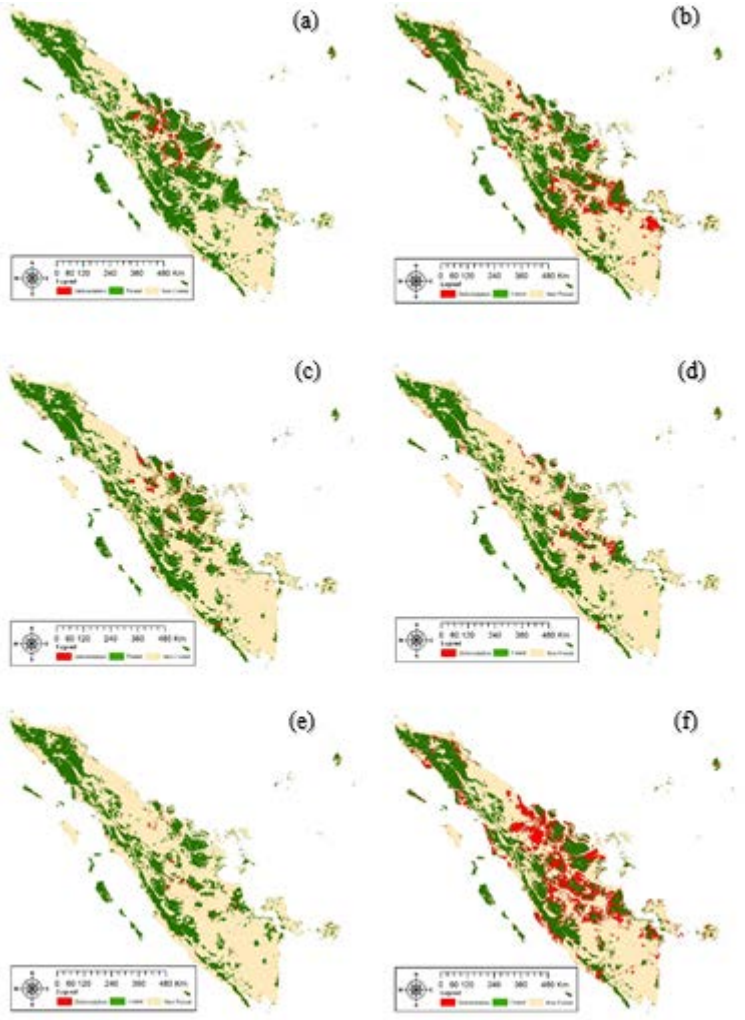

Figure 3: distribution of deforestation in Sumatra Islands; 1990-1996 (a), 1996-2000 (b), 2000-2006 (c), 2006-2011 (d), 2011-2013 (e), 1990-2013 (f)

Finally, at last period (2011-2013), deforestation was still happening despite there was a tendency to decrease in provin ces of South Sumatra, West Sumatra, Bengkulu, Riau and Jambi. Throughout the observation period, deforestation was showing a declining trend. Precisely, it was caused by declining availability of forest area [40]. The analysis showed also that the highest deforestation in Sumatra occurred in Riau Province (56%). Deforestation of Riau was nearly 50% of total deforested areas throughout Sumatra from 1990 to 2011 [40].

The study also examined patterns and processes of deforestation which had been carried out. However,

information about factors that affect deforestation is still lacking [1]. Three major causes of deforestation is agricultural expansion, timber harvesting, infrastructure development and five driving force (demographic, economic, technological, policy and institutional and cultural factors) [1, 59].

The main driver of deforestation is agriculture, both for crops and livestock [60]. In addition, drivers of deforestation and forest degradation in tropical areas are shifting cultivation, agricultural land, livestock, logging (for industrial wood and firewood), draining and burning peat land, plantations, and forest fire. Furthermore, changes in land use can be affected by topography, accessibility, distribution of urban land and agricultural land. In detail, land distribution factors were significantly associated with GDP per capita. Deforestation also occured faster in flat and low land [61]. Level of low to medium slope shows a high degradation over steep slopes. This area is used for agriculture, horticulture, agro-forestry and local grazing [62].

3.2. Deforestation profile at regency level in Sumatra Islands

Based on analysis of deforestation profile, it is obtained an information that deforestation of Sumatra Islands at regency level from 1990 to 2013 was dominated by Small-profile Early-Low Deforestation. Small-Early-Low Deforestation is deforestation in areas with low forest cover and occurred in first period with a high rate in initial period. This profile was exposured in 48 regencies/cities (31.58%). Moreover, next highest deforestation incident was categorized as Small-profile Lately-High Deforestation. This profile was demonstrated in 34 regencies/cities (22.37%). Small-Lately-High Deforestation means that deforestation occurs in areas with high forest cover with low deforestation rates and high rates of deforestation by the end of observation period. The third deforestation profile is most-Early Large-Low Deforestation. This profile means deforestation in areas that have high forest cover, land area and high rates of deforestation occurred in initial period. Large-Early-Low Deforestation was exposured in 26 regencies/cities (17.11%). while next-Lately Large-High occured in 18 regencies/cities (11.84%). Furthermore, Large-Early-High occurred in four regencies/cities (2.63%), Small-Latetly-Low occurred in two regencies/cities (1.32%) and Small-Early-High was exposured in two regencies/cities (1, 32%). Fortunately, large profile-Low-Lately occured only in one regency (0.66%). Number of regencies/cities that do not have a forest by the first period of observation (1990) was 12 regencies/cities (7.89%). Deforestation did not happen in five regencies/cities (7.89%). Five regencies/cities had profiles of Non-Small Deforestation, i.e. Bandar Lampung, Palembang, Pangkal Pinang, Solok and Samosir. Non-Large Deforestation profile was not found during the observation period. The highest profile Small-Early-Low Deforestation and Small-Lately-High Deforestation indicated that dominant deforestation was exposured in regencies/cities with small forest area.

Deforestation profile indicated that deforestation in Sumatra was strongly associated with development of Indonesia in two phases. First, it was called Orde Baru phase (1990-1998) and second, the reform phase (1998-2013). Orde Baru phase argued that timber forest products as financial support for national development. The reform phase was started by implementation of decentralization law number 22 in 1999 [63].

Figure 4 shows profile of deforestation in each regency/city in Sumatra Islands from 1990 to 2013. It informs difference of deforestation profile that occurred from beginning to the end period. In addition, the image also

show regencies/cities that were not experiencing deforestation and regencies/cities without forest area. During the time, there were only depiction forests or deforestation rate through extensive deforestation [39-41, 55-57]. As a result, meaning of forest lost or deforested was reflected by high rate value. The higher deforestation rate, the higher deforestation. High deforestation rate in general is associated with loss of vast areas of forest. This study found that rate of high value at a regency/city was not automatically linear to deforested forest area. Other findings was about rate value reflecting forest condition of a certain area. Low rate value does not always reflect forest state better than it of a high rate. Moreover, low deforestation rate in some regencies/cities in Sumatra were started from small forest area. It was caused by deforestation in previous period. In addition, there were areas with no forest areas [40].

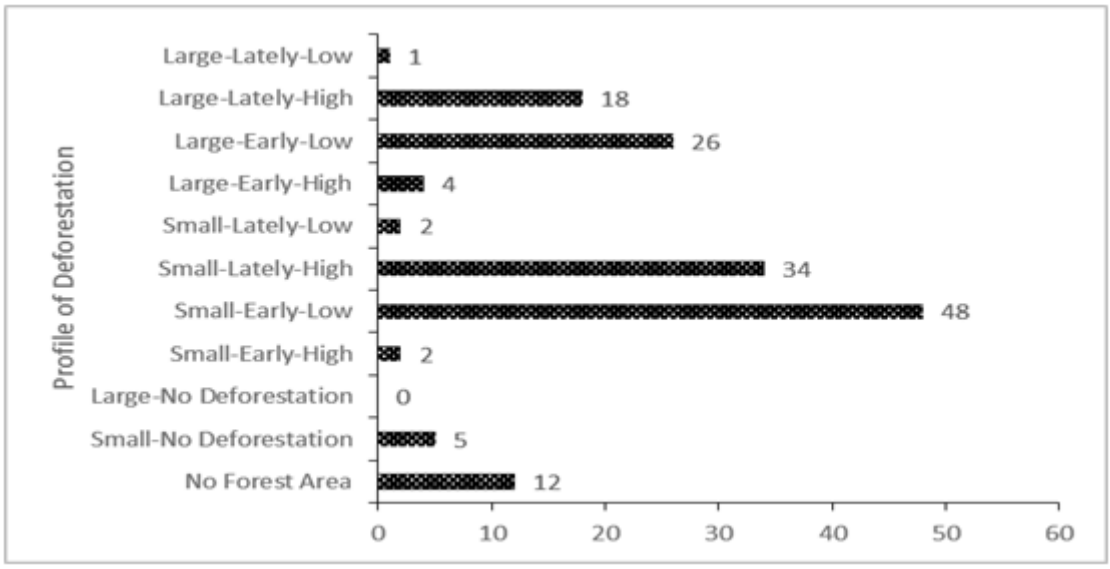

Figure 4: profile of deforestation in Sumatra Islands 1990¬-2013 period

Deforestation profile has been able to explain and describe better about deforestation in an area or region compared to other methods before. Rate of small value (up to 0) is able to be better understood and described. Generally, rate value can be significantly devided into two different occasions. Firstly, it means an area without deforestation and the forest is maintained. Secondly, it means an area without deforestation because the forests have been depleted. However, some improvements to assessment methode affecting deforestation rate is quite necessary. Deforestation profile becomes one of better assessments so far.

Deforestation in Sumatra Islands could also be based on proportion or availability of early forests (1990). Table 1 showed that early forest area influences extensive deforestation. The highest initial forest area was in Riau Province (5,657,461.03 hectares) and the lowest was in Riau Islands Province (320,005.66 hectares). Moreover, the highest deforestation was also occurred in Riau Province area (3,857,504.81 hectares) and the lowest was also in Riau Islands Province (52,087.36 hectares). Furthermore, table 1 also informed that proportion of early forest area compared to highest area were Aceh Province (64.9%), Riau Province (63.0%), West Sumatra Province (58.9%) and Edinburgh (57.0%). Additionally, proportion of deforestation initial forest area was occurred in Riau Province (68.18%), Jambi Province (56.86%) and South Sumatra Province (56.51%). The highest deforestation generally was exposured in first period (1990-2000) or Early Deforestation. Lastly, the

highest deforestation at end period (Lately Deforestation) was only occurred in Riau Islands Province. Riau Province and Jambi Province also had a deforestation profile of Large-Early-Low, meanwhile Riau Islands Province is Small-profile Latey-High deforestation.

Table 1: Early forest area, province wide, extensive deforestation, proportion of early forest within province, proportion of early deforestation per area at provincial level from 1990 to 2013 in Sumatra

Province	HA 1990	LPROP	DEF	PLHP	PDLH	PD I	PD II
Bengkulu	1.008.888,7	2.000.562,5	311.674,8	50,4	30,9	64,9	35,1
Jambi	2.801.123,7	4.918.211,9	1.592.653,9	57,0	56,9	58,6	41,4
Bangka Belitung Islands	393.555,4	1.666.532,4	135.286,9	23,6	34,4	53,3	46,7
Riau Islands	320.005,7	811.216,1	52.087,4	39,4	16,3	47,1	52,9
Lampung	373.475,9	3.355.535,8	78.718,9	11,1	21,1	84,2	15,8
N. Aceh Darussalam	3.753.162,3	5.783.447,5	564.955,2	64,9	15,1	61,8	38,2
Riau	5.657.461,0	8.979.417,2	3.857.504,8	63,0	68,2	50,2	49,8
West Sumatra	2.499.980,6	4.242.968,1	535.731,2	58,9	21,4	50,4	49,6
South Sumatra	2.125.066,0	8.635.382,4	1.200.936,1	24,6	56,5	80,5	19,5
North Sumatra	2.252.723,1	7.300.376,6	531.576,7	30,9	23,6	52,2	47,8
TOTAL	21.185.442,5	47.693.650,4	8.861.125,7				

Note:

HA 1990: early forests 1990 (ha); LPPROP: provincial size (ha); DEF: deforestation period 1990-2013 (ha); PLHP: proportion of forest area, started by provincial area (%); PDLH: deforestation proportion at early forest area (%); PD I: deforestation proportion in 1990-2000 (%); PD II: proportion deforestation in 2000-2013 (%)

The results showed required information in addition to rate and total area of deforestation. The additional information is information of initial forest cover and deforestation at certain period (early or late). Deforestation profile has accommodated such information. The profile has been able to describe circumstances and events of deforestation better. In addition, vast proportion of deforestation (by initial area and total area) can also add significant information on understanding deforestation in certain area.

4. Conclusion

The research results showed that deforestation rate solely is not enough to describe the incidence of deforestation. Profile of deforestation is an alternative analysis to obtain better information. There were ten deforestation profiles for ten provinces (152 regencies/cities) in Sumatra Islands. Furthermore, deforestation in Sumatra was dominated by Small-profile Early-Low Deforestation in 48 regencies/cities (31.58%). Small profile was the second most-Lately-High Deforestation in 34 regencies/cities (22.37%). Moreover, number of regencies/cities that did not have a forest were 12 regencies/cities (7.89%). In detail, Small profile-No

Deforesation occurred in five regencies/cities (3.29%). At provincial level, Riau was the province that had highest forest cover (1990) with highest deforestation (68.18%). In contrary, Riau Island was a province with lowest forest cover with low deforestation (16.28%). In summary, deforestation at provincial level in Sumatra Islands from 1990 to 2013 was categorized as Early Deforestation (90%).

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