Land use changes and plantation crop development in selected provinces in Sumatra and Kalimantan

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Abstract. Most institutions stated that biofuel will not qualify the standard of GHG emission reduction if it was produced in the plantation associated with the forest conversion. Therefore, knowing previous land use before the development of plantation is very important. In Indonesia, plantation development occurs mainly in Sumatra and Kalimantan. A number of studies had been published showing historical LUCC before plantation development. Objective of this study was to review various studies on LUCC carried out in four selected provinces, namely West Kalimantan, Central Kalimantan, East Kalimantan, and Riau. The analysis and comparison was based on the different source of historical data including online spatial data sources and various studies published in various journals. Each data source of LUCC shows significant variation on the amount of plantation developed directly from forest and other land use types. But, our review showed that the plantation areas associated with the forest cover changes far less than those claimed by several international journals. But, the debate concerning which plantation developments indirectly contributed to LUCC and which are directly will probably continue until the information on the land ownership and history of plantation development is available publicly.

1. Introduction
In Indonesia, the area of the oil palm plantation increased from 0.7 million ha in 1990 to 12 million ha in 2017 [1,2], and further millions of ha are projected to be required in 2020–2050 [3,4]. This rapid expansion of the plantation crop has been partly triggered by an increased demand for biofuel production [5]. In addition, rubber plantations, which are also prevalent in Southeast Asia [6], currently cover 3.5 million ha of land in Indonesia [1].

The development of the plantation crop as a result of the conversion of primary and secondary forests will release respectively between 270–530 and 120–190 g CO2 equivalent for each MJ produced biodiesel. In contrast, the conversion of the degraded lands results in the capture of between 23 and 85 g CO2 equivalent per MJ of biodiesel produced. According to EPA’s analysis, biodiesel produced from plantation grown by conversion of primary and secondary forests do not meet the minimum 20% lifecycle GHG reduction threshold required to qualify as renewable biofuel [7].

Some international publications [8,9] claimed that more than 50% of Indonesian plantation crop were developed on the forest areas. The objective of this study was to review various data sources related to the amount of plantation developed on the forest area. We selected 4 provinces in Sumatra and Kalimantan representing areas with extensive plantation crop development, namely West Kalimantan, Central Kalimantan, East Kalimantan, and Riau. According to Ditjenbun [1], plantation area in all four provinces entail to almost 50% of total plantation in Indonesia equivalent to 5.5 Mha. Sumatra and Kalimantan are the main plantation area and they entail to 89% (10.7 Mha) of the total plantation crop area in Indonesia [1].

2. Methodology
We reviewed various published studies related to the plantation development associated with the LUCC in four provinces where intensive development of plantation has been going on including West Kalimantan, Central Kalimantan, East Kalimantan, and Riau.
In Indonesia, development of plantation crop occurred since 1970s, but rapid increase of the plantation expansion by smallholders and private companies started since 1990 [1,10]. The plantation concession maps for the study areas were obtained from different sources. The concession map is an indicative area owned by plantation company. Real planted areas are usually less than the concession area, the reason is that some of the concession area have not been planted by crops. On the other hand, some plantations were found to be developed outside the concession [9].

To obtain actual planting area inside concession map, we used 2 approaches a) cross checking with statistical data from National Plantation Office or Ditjenbun [1], and b) comparing with spatial data from Atlas-CIFOR (cifor.org/map/atlas, [10]). The spatial data from Atlas-CIFOR was based on the detail study carried out by Gaveau et al. [10]. The latest version of the Atlas-CIFOR (launched November 2017) allows user to verify the location and ownership of the concessions and planted oil palm in Kalimantan. It can tract the LUCC footprint of plantation companies (cifor.org/map/atlas). All the maps presented in the Atlas-CIFOR (cifor.org/map/atlas, [10]) underwent a rigours peer-review and published here [10].

3 Result and Discussion

3.1 Plantation development and LUCC based on various data sources

According to Koh and Wilcove [8] during the period of 1990–2005 most of the plantation expansion in Indonesia occurred by forest conversion based on FAO data. However, the accuracy of this statement has been questioned [9,11].

Carlson et al. [9] quantified plantation development across Kalimantan from 1990 to 2010 using Landsat data. Gunarso et al. [16] reported that from 1990 and 2010, only 36.5% of all oil palm plantations were developed in the forest area, including both upland and swamp habitats and only 0.1% and 4% of oil palm plantations were developed on the primary forest and natural swamp forest respectively from 1990 and 2010.

Tarigan et al. [14] investigated in Merangin and Bungo Districts, Jambi province and showed that in the year from 1988 and 2013, only a small fraction of the oil palm expansion (8%) occurred by direct conversion of primary forest in the study area. Most of the oil palm expansion occurred in other land use types such as logged-over forest, shrub land and agroforest.

Among all available studies dealing with the plantation development and associated LUCC, Gaveau [10] is considered as one of the most reliable and comprehensive source to tract the LUCC footprint of plantation companies in this study. According to Gaveau [10], Kalimantan experienced extensive forest conversion before the expansion of industrial plantations. In the period of 1973-2015, the total development of the plantation (both plantation crop and pulpwod) in Kalimantan summed up to 5.6 Mha. Some 1.3 Mha and 1.2 Mha of those were developed in non-forest area and scrub respectively in the period of 1973-2015. In Kalimantan, only 11–13% of all forest conversion was related with the plantation expansion as the plantation development dominantly occurred on the lands previously cleared before 1973 [10]. Gaveau [10] further concluded that the debate concerning which plantation developments cause indirectly forest conversion and which are directly will continue until the data of the land ownership is made available to the public.

3.2 Plantation concession and planted area based on the different data sources

Our review showed that 3 Mha concession area have not yet been converted to plantation (figure 1) in West Kalimantan. This figure is similar to that showed by Atlas-CIFOR [10]. In West Kalimantan, there is data consistency between Ditjenbun [1] and Atlas-CIFOR [10] on the actual plantation area which is of ~1.4 Mha (figure 1).
Our review in Central Kalimantan showed that 3 Mha of the concession area have not yet been converted to plantation (figure 2). Meanwhile, Atlas-CIFOR [10] showed that 1.2 Mha of the concession area have not yet been converted to plantation. In Central Kalimantan, there is data consistency between Ditjenbun [1] and Atlas-CIFOR [10] on the actual planted oil palm area which is of ~1.2 Mha.

Our analysis showed that 2.4 Mha oil palm concession area have not yet been utilized (figure 3) in the East Kalimantan. Meanwhile, Atlas-CIFOR [10] showed that 1.2 Mha oil palm concession area have not yet been converted to plantation. In East Kalimantan, there is difference between Ditjenbun [7] and Atlas-CIFOR [10] on the actual planted oil palm area during 1973-2015 which is of 0.5 and 0.7 Mha respectively.

Our review showed that the total amount of the oil palm concession area, which have not been planted in West, Central and East Kalimantan was 8.4 Mha. According to Austin et al. [15], there are 8.6 Mha of concession area planned for oil palm expansion in Kalimantan which have not yet been developed to plantations. Thus, our analysis and that of Austin et al. [15] showed similarity. Meanwhile
Gaveau et al [10, Atlas-CIFOR] reported that 6.6 Mha out of 10 Mha concession area planned for oil palm expansion in Kalimantan have not yet been developed to plantations. On the other hand, two studies in Kalimantan using medium-resolution LANDSAT satellite imagery found that nearly a quarter of oil-palm plantations from 1990 and 2010 were outside legal concessions, proving the need to investigate outside concessions to identify impacts of plantation development on the forest conversion [9,15]. The Atlas-CIFOR [10] does not cover Riau province. But our review on the total area of the oil palm concession in Riau showed similarity with those showed by Ditjenbun [1] which are ~ 2.2 Mha (figure 4). According to Susanti and Burgers [12], some forest area allocated for oil palm plantation Riau province. Santosa et al. [13] investigated previous land use of oil palm in 8 big companies of oil palm plantation covering an area of 46,372.38 ha and concluded that most of the plantation was established in non-forest area.

![Figure 4. Concession and planted area based on the different sources in Riau Province.](image)

3.3 Comparison of forest cover change in the study areas
Despite the largest oil palm plantation area (~2.2 Mha), Riau Province has the lowest percentage of oil palm plantation associated with direct LUCC. On the average, the proportion of oil palm plantation associated with direct LUCC in the selected provinces is less than those claimed in the international journal publication.

Concern of international communities on the tropical LUCC often focus on the GHG emission and biodiversity issues. These issues often not become of primary concern of the local communities around the LUCC sites. We need to investigate the relation of the LUCC with local environmental services issues [17, 20, 21]. These issues directly affect local communities around LUCC sites. According to Tarigan [2], flooding frequencies increased in the last decades in Jambi province along with the land use change this province. By associating LUCC with the local issues, there is incentives for local communities to implement mitigation option associated with the oil palm expansion. Simple mitigation option [18, 19] are often effective to mitigate impact of LUCC.

4. Conclusions
According to our review, the plantation development associated with direct LUCC in the four selected provinces is far less than those stated by the several international journals. The plantation activities occurred dominantly on logged-over area cleared before the plantation development.

The debate concerning which plantation developments indirectly contributed to LUCC and which are directly will probably continue until the information on the land ownership and history of plantation development is available publicly.

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