Economy and environmental impacts of oil palm plantation expansion in Mamuju Tengah district, West Sulawesi Province, Indonesia

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Abstract. The expansion of oil palm plantations in Indonesia has led to massive land conversion. At present palm oil in West Sulawesi is the largest oil palm plantations in eastern Indonesia, the development of oil palm which is so rapidly affected by the level of income received by the community when farming oil palm compared to developing other types of plantations such as rubber, coconut, or other types of plantation crops. The growing development of oil palm plantations today is feared to affect biodiversity, which results in changes in the environmental ecosystem in West Sulawesi, especially in Central Mamuju District. Changes in the environmental ecosystem can cause conflicts between humans and animals as a result of the reduced natural habitat of animals, which is the impact of oil palm plantations. This article will explore the environmental and economic impacts arising from oil palm expansion in Central Mamuju Regency, West Sulawesi Province. This research was conducted with a descriptive method to describe the impact of plantation expansion in the Central Mamuju Regency. The results of the study show that there was a change in the environmental ecosystem in the Middle Mamuju Kapubapaten, which resulted in conflicts between humans and animals. As for the economic impact, there was an increase in farmer's income.

1. Introduction
Oil palm is one of the commodities of plantation products that has an important role in economic activity in Indonesia because of its ability to produce vegetable oil, which is much needed by the industrial sector. As the largest oil palm producing country in the world, Indonesia has great potential to market oil palm and nucleus oil palm both domestically and abroad.

According to BPS data, 2018, West Sulawesi Province is the largest producer of oil palm in Eastern Indonesia, and one of the oil palm producing regions in West Sulawesi Province in Central Mamuju District [1]. Mamuju Tengah district is the result of the division of the Mamuju district in 2012. The results of the division included five (5) sub-districts, namely Tobadak, Pangale, Budong Budong, Topoyo, and Karossa sub-districts. In total, the area covers 3,100.87 km², with the total population reaches 143,946 people in 2017 [2].

Oil palm plantation is one of the economic, strategic programs of the government of Central Mamuju District, where the amount of oil palm production is highest compared to other plantation commodities (Table 1). The development of the oil palm sector is very significant, especially in 2015
to 2016, with an increase in oil palm production reaching 68.1%. The spread of oil palm plantations is found in all districts in Mamuju Tengah [2].

Table 1. Development of plantation commodities in 2015-2017 of Mamuju Tengah

| No | Commodity      | 2015  | 2016  | 2017  |
|----|----------------|-------|-------|-------|
|    | Harvested area (ha) |       |       |       |
| 1  | Oil Palm       | 16,222| 41,641| 47,587|
| 2  | Cacao          | 21,966| 15,232| 15,064|
| 3  | Coconut        | 1,435 | 1,435 | 1,435 |
| 4  | Clove          | 89    | 141   | 181   |
| 5  | Pepper         | 25    | 25    |       |
| 6  | Nutmeg         | 23    | 28    | 32    |
| 7  | Robusta Coffee | 172   | 173   | 34    |
| 8  | Candle nut     | 281   | 7     | 7     |
| 9  | Sugar Palm     |       | 20    | 20    |

|    | Productivity (ton/ha) |       |       |       |
| 1  | Oil Palm          | 2,598 | 3,419 | 3,376 |
| 2  | Cacao             | 738   | 708   | 701   |
| 3  | Coconut           | 255   | 554   | 897   |
| 4  | Clove             | 160   | 677   | 625   |
| 5  | Pepper            | -     | 538   | 571   |
| 6  | Nutmeg            | 23    | -     | 200   |
| 7  | Robusta Coffee    | 333   | 696   | 609   |
| 8  | Candle nut        | 312   | 1,091 | 833   |
| 9  | Sugar Palm        |       | 20    | 20    |

|    | Production (Ton) |       |       |       |
| 1  | Oil Palm         | 34,941| 109,632| 106,383|
| 2  | Cacao            | 9,356 | 7,213  | 6,789 |
| 3  | Coconut          | 253   | 961    | 890   |
| 4  | Clove            | 12    | 60     | 61    |
| 5  | Pepper           | -     | 7      | 8     |
| 6  | Nutmeg           | 23    | -      | 0     |
| 7  | Robusta Coffee   | 44    | 90     | 14    |
| 8  | Candle nut       | 67    | 6      | 5     |
| 9  | Sugar Palm       | -     | 20     | 17    |

The expansion of oil palm plantations has an impact on the environmental and economic problems of the local community. There have been many empirical studies in various places related to the impact of the development of oil palm plantations on environmental damage [3,4]. According to Susila (2004), the palm oil industry has an important contribution and role in increasing income distribution, economic growth, and poverty alleviation. The development of palm oil has a positive impact on economic growth as indicated by investment, output, and foreign exchange growth [5]. The palm oil-based industry also has a significant contribution to the welfare of households working in the palm oil industry [5,6]. In addition to obtaining economic benefits, the expansion of oil palm plantations has great potential for environmental problems [7]. The expansion of oil palm plantations can cause deforestation, increase carbon emissions, and climate change so that it can disrupt environmental conditions [8].

In addition, the expansion of oil palm plantations will create opening opportunities for the development of the processing industry crude palm oil (CPO). These industrial activities have an impact on society located in an industrial area. Impact arising is waste disposal from processing CPO industry activities is polluting the environment around the factory. Stinging odors from oil palm processing wastes are common. Based on this, it needs to be assessed the impact of oil palm expansion
is seen from two aspects, namely economic and environment. The purpose of Paper's writing is to determine the environmental and economic impacts resulting from the expansion of oil palm plants in the Central Mamuju Regency.

2. Methods
This research is a literature study by analyzing and analyzing journals related to the economic and environmental impacts of oil palm plantation expansion in several regions. The study was conducted using descriptive qualitative methods to illustrate the impact of oil palm plantation expansion in the Central Mamuju Regency. Data collection is done by documentation techniques by tracking documents and information related to the topic being studied. Data analysis was carried out through the stages of data reduction, data presentation, verification, and conclusion drawing [9]. The results of this literature review will be used to identify the potential economic and environmental impacts of oil palm plantation expansion that might develop in Central Mamuju.

3. Result and analysis
Production volumes of palm oil (palm oil) or Crude Palm Oil (CPO) tend to increase from 2000 to 2018 (Figure 1). The Indonesian Plantation Statistics Report on Palm Oil released by the Directorate General of Plantations notes that production volume in 2018 increased significantly by 43.9 million tons or 19.36 percent compared to the previous year [10].

![Figure 1. Oil palm production volume (CPO), 2000-2018](image)

Palm oil is the preferred cooking oil for millions of people around the world and a source of biodiesel. Palm oil and its derivatives are commonly used ingredients in many cosmetics, household cleaning, and fast food products. Palm oil production is projected to continue to increase in line with high market demand, which has led to a nearly double increase in palm oil production between 2003 – 2013 [11]. When measured in terms of production and importance in trade, palm oil products are the most important tropical vegetable oils globally, accounting for one-third of the production of vegetable oils in 2009 [12]. Palm oil products dominate compared to other vegetable oil crops, it can be explained from the results of oil palm plants that are more than four times that of other oil plants [13], oil palm is much preferred because it is a versatile product as an ingredient in various products by and low price [13,14]

3.1. Analysis of impacts
The environmental impact arising from oil palm expansion is the focus of discussion and concern; the expansion of oil palm plantations is a major factor in habitat loss and deforestation in Indonesia and elsewhere. In the implementation of discussion forums, the issue of biofuels has always been the main topic where the need to reduce carbon use is a concern related to the conversion of peatlands and forests [15]. But besides that, the issue of socio-economic impact becomes a lot of things discussed
besides the issue of environmental impact. The central government justified allowing the expansion of biofuel development and oil palm expansion in Indonesia under the pretext of job creation, poverty alleviation, and rural development [16].

3.2. Economic impact
Globally, as the world's largest producer and exporter of palm oil, Indonesia produces almost 50% of total world palm oil production [17]. World palm oil production is approved by Indonesia and Malaysia. 80% of the total world palm oil production [17,18]. Indonesia's total production for 2016 is able to produce up to 36 million tons of crude palm oil, and 85-90% of this amount is exported to various countries such as India, China, Pakistan, Bangladesh, the United States, the Netherlands, Spain, Italy, Egypt, and Malaysia and the remainder is for domestic consumption. The results of Indonesia's palm oil exports in 2016 were able to generate revenues of USD $ 18.6 billion from 32 million tons of palm oil exports. Palm oil is the largest agricultural industry in Indonesia [17]. As a result of increasing global demand that continues to increase and also rising, the development of oil palm plantations continues to increase significantly both by smallholders and large entrepreneurs in Indonesia so as to increase production will continue to increase by around 10% per year [19]. In the period 2006 to 2015 alone, the area of oil palm plantations in Indonesia increased from 4.1 million ha [20] to around 8.9 million ha [17], so that by 2025, Indonesia's oil palm land area is expected to grow to reach 17 million ha [21]. With the rapid development of the palm oil industry, it directly contributes positively to the Indonesian economy, with around 7.5 million people working in the palm oil industry [21], and is an important source of income for the Indonesian population [17].

In Mamuju Tengah itself, oil palm is the leading commodity with the highest productivity compared to other plantation commodities. Oil palm has replaced the role of rubber commodities that previously dominated the economy. The oil palm sector is the main driver in development. An increase in community income from the oil palm sector, both as an oil palm farmer as well as being a laborer and staff of an oil palm plantation company. For salaries of workers in oil palm companies receive around 2.7 million / month [22].

3.3. Environmental impact deforestation
The palm oil industry in Indonesia faces two very daunting challenges, namely peatland exploitation, and deforestation associated with high levels of carbon emissions [20]. Deforestation of tropical rain forests or secondary forests to be replaced with oil palm plants can cause serious disturbance to biodiversity in Indonesia [23,24]. Obidzinski et al. (2012) Various report evidence shows that the expansion of oil palm plantations in Indonesia targets forest land (shrubs) to become new plantation areas. It is very important to discuss to find out to what extent oil palm expansion results in deforestation or has become a major cause of deforestation [20,25]. According to Gunarso et al. (2013) based on a detailed land-use matrix, it was found that in the decade 2000-2010, around 19% deforestation and 35% conversion of peatlands was carried out to open up oil palm plantations so that 1.1 million ha of forest land (of various types) and 0.7 million ha of converted peatlands [19,25].

However, Oil palm is the biggest provider of oils and fats for the world and also the most efficient in terms of land use among the competing oil crops. The oil palm is over ten times more productive than that of the next major edible oil in the market. In comparison with other edible oils, oil palm production is arguably more environment-friendly for at least two reasons. Firstly, oil palm occupies the least area of global oilseed production. Secondly, a hectare planted with oil palm yields about four tonnes of oil per year on average. In contrast, to produce that much oil from soybean, sunflower, and rapeseed, up to ten times more land would be required [26]

3.4. Biodiversity on plantations
Oil palm plantations indirectly cause a reduction in biodiversity in an area more than other types of plantation crops, although not all biodiversity is reduced. Fitzherbert et al. (2008) found that although all types of plantations reduce species richness in an area compared to forests that are still in natural
conditions, oil palm plantations have a greater contribution to the reduction in the number of species compared to the collection of cocoa, coffee or rubber [27].

The reduction in the number of species in an area will affect the environment and cause conflicts between humans and predatory animals due to the reduction in natural prey in the forest. Such was the case in Central Mamuju District when an oil palm farmer was killed by a python when he was a memamen palm as a result of reduced natural prey animals such as wild boar, monkeys, or other animals. In addition, the expansion of oil palm in the Mamuju Regency is being feared that it will cause a decline in the natural habitat of Sulawesi’s endemic maleo birds, resulting in a population reduction. Peh et al., (2006) suggested that there was a 14% decrease in bird diversity attributable to the conversion of rubber plantations to oil palm [28]. The most severe impacts of oil palm plantations are driven by a number of factors including the use of hazardous chemicals, changes in forest structure, and human conflicts with animals [17].

Comparison between oil palm plantations and natural forests is very far in terms of preserving the environment; oil palm plantations are far less complex because they have rare undergrowth, uniform tree age structure, and lower canopy heights [24]. When natural forests are converted to oil palm plantations, the number of vertebrate, mammal, bird, and lizard species decreases. The survival of primary forest species that can be supported by oil palm plantations is only around 15 to 23% [27,29]. When primary natural forests are converted to oil palm plantations, there is a 77% decline in species richness of birds, and when selective secondary forests are converted, 73% decrease [17,28].

The adverse effects of oil palm plantations are also felt by invertebrate species. Although the role is not directly apparent, invertebrate species play an important role in the functioning of ecosystems, a decrease in the number of invertebrates will have a long-term effect on [17]. For example, if the number of large-bodied beetles decreases as a result of the loss of natural habitat and only separates small-bodied beetles, but small-bodied beetles do not have the same function as large beetles in the ecosystem. The absence of large beetles will damage the functioning of the ecosystem because their manure functions as an organic material and helps maintain soil nutrition [17,30]. Senior et al. (2013) concluded that after the conversion of forests to oil palm plantations, the wealth of beetle and ant species decreased by 52% and 61%, respectively [31]. After primary and secondary forest conversion, the richness of forest butterfly species decreased by 83% and 79% [23].

Oil palm plantations do not have complex biodiversity for ecosystems compared to tropical forest flora. The main components of forest vegetation are completely absent from oil palm plantations and do not have native palm trees, lianas (wood vines), and epiphytic orchids [29]. Various studies show that the expansion of oil palm plantations will damage biodiversity and balance the ecosystem. Some species that are able to survive on oil palm plantations will become dominant, while certain species that are unable to adapt will be eliminated [17].

3.5. Carbon balance

There are two main components that contribute to the greenhouse gas effect in the palm oil industry, namely, emissions from land conversion and emissions from palm oil processing [17]. The amount of carbon emissions in the land conversion process depends on the previous land cover and soil type. Different land cover, such as primary forest, secondary forest, former plantation land, abandoned land, shrubs, and others, have different stored carbon stocks. Whereas the type of soil is divided into two, namely mineral soil and peat soil. Peat soils formed from the remnants of organic matter have far greater carbon stocks than mineral soils.

Destruction of tropical rain forests poses a serious threat to climate stability because tropical forests store large amounts of carbon. The second-largest source of greenhouse gas emissions is land-use change in the tropics, accounting for 12-20% of total global emissions [32]. The expansion of oil palm plantations has resulted in deforestation, resulting in the impact of reduced carbon stocks in the soil and removal of biomass [17,33].

Carbon content stored in biomass in tropical forests ranges from 41.5% to 50%, forests in Indonesia are estimated to have stored carbon stocks of between 161 tons ha-1 to 300 tons ha-1. Plant
biomass in wetland/peatland forests stores around 200t C ha\(^{-1}\). The average sequestration (anchoring) of carbon in oil palm plants is only 60 tons ha\(^{-1}\) [34].

Land clearing for plantations is mostly done by cutting down and burning trees or Imperata (slash-burn systems). Burning vegetation results in almost all of the C and N reserves being lost. If the peat forest biomass burns, not only will the biomass of the plant burn, but also a few centimeters of the peat top layer is dry. This peat layer will be prone to fire if the groundwater level is deeper than 30 cm [34].

Whereas in Processing, oil palm requires the use of fossil fuels for mechanical plantations, chemical fertilizers, and industrial processing that produces waste. The use of fossil fuels for mechanical equipment also produces emissions. Estimates (ERIA, 2007) revealed that diesel consumption was 58-70 liters ha\(^{-1}\)th\(^{-1}\) in oil palm plantations, and the equivalent CO\(_2\) emissions of 3.1 kg/liter of diesel fuel were equivalent to 180-217 kg equivalent of CO\(_2\) ha\(^{-1}\) years old [34].

The carbon emissions and absorption balance also depend on the level of plantation management. A good fertilizing treatment will fertilize plants so that it will absorb (tethering) carbon dioxide (CO\(_2\)) from the air in the process of photosynthesis and stored in the form of plant biomass while the type of fertilizer that contains nitrogen elements will emit greenhouse gases, which is in the form of methane (NH\(_4\)). The management of organic material remnants from plantations will also affect the number of carbon emissions [34].

Palm oil mills produce liquid waste known as Palm Oil Effluent (POME) - a brownish-colored liquid that contains inorganic and organic solid waste, a little palm oil, and water. POME is usually handled using the anaerobic decomposition process in open ponds, which has experienced a reduction in toxicity. Methane gas is produced during the breakdown of anaerobic bacteria from the Palm Oil Mill Effluent (POME), and is 34 times more dangerous than carbon dioxide (CO\(_2\))\(^3\). The processing of palm oil mill waste that releases large amounts of methane, this is a strong climate trigger. deforestation and land conversion to be the largest source of greenhouse gas emissions for palm oil production, while methane from mill effluents and nitrous oxide from fertilizers is the second largest contributor [34].

3.6. Groundwater drainage and surface water pollution
Related to environmental disturbance due to oil palm expansion wherein a study carried out in Gading Beach, South Africa, it was mentioned that one oil palm tree trunk requires water of 1.25-2.31 mm/day and can absorb water to a depth of 5.2 m [35]. Another study by Kallarakal et al. (2004) oil palm plantations can disrupt groundwater supplies for other plants outside oil palm plantations because of the depletion of groundwater by plantations palm very much [36]. Kallarakal, in his study in India, revealed that the average water needed for a single palm tree was 2.0-5.5 mm/day or 140-385 l/ha/day with a total of 143 trees/ha [36]. According to Tauqiq et al. (2013), more than 30% of land use in the Hedgehog Sub-watershed is used as an oil palm plantation area; this will be has a big impact on water balance because the water demand for oil palm is very great [37]. It is known that the percentage of the effect of reducing the flow of water due to oil palm plantations ranged from 30-40% [37]. The existence of oil palm plantations, access to water becomes difficult for the local community. Furthermore, Many residents around the plantation area complain that the river in their village has decreased, even dried up, and the water is dirty, after the entry of oil palm plantations in these areas their well water is getting deeper, and the frequency and intensity of floods are increasing [35].

4. Conclusion
The environmental impact arising from the expansion of oil palm plantations in central Mamuju district based on literature studies from various sources can be concluded that there has been a change in the environmental ecosystem, with the occurrence of conflict between humans and animals, human cases were devoured by pythons as a result of the reduced natural prey (pigs forest and monkey) available in the forest. In addition, one of the environmental impacts of oil palm expansion is the reduction in the population of Sulawesi’s endemic animals Maleo birds in Central Mamuju District due to the reduction in natural habitat.
The expansion of oil palm plantations in Mamuju district is causing farmers to convert some or all of the plantations into oil palm plantations. The conversion resulted in a change in income structure from (rubber, cocoa, and others) to oil palm. This resulted in an increase in farmers’ income. Expansion of oil palm plantations does not always have a negative impact, but can also provide benefits, so it is necessary to have the best solution to limit the expansion of oil palm plantations and reduce the negative externalities of the CPO processing industry.

References

[1] Statistik B P 2018 Statistik Kelapa Sawit Indonesia 2018 (Badan Pusat Statistik)
[2] Mamuju Tengah Bappeda 2018 Profil Mamuju Tengah
[3] Susanti A and Maryudi A 2016 Development narratives, notions of forest crisis, and boom of oil palm plantations in Indonesia For. Policy Econ. 73 130–9
[4] Puspitasari D, Salman D, Rukmana D and Demmallino E B 2019 Household vulnerability located on land conversion for palm: Case study of pinrang sub-district, wajo district, South Sulawesi IOP Conf. Ser. Earth Environ. Sci. 235
[5] Susila W R 2004 Contribution Of Oil Palm Industry On Economic Growth And Poverty Alleviation In Indonesia Wayan R. Susila Economic crisis hitting Indonesia since July 1997 has paralyzed most economic sector in Indonesia. The rate of inflation jumped to 77.63 % in 199 J. Penelit. dan Pengemb. Pertan. 23 107–13
[6] Utami R, Kumala Putri E I and Ekayani M 2017 Economy and Environmental Impact of Oil Palm Plantation Expansion (Case Study: Panyabungan Village, Merlung Sub-District, West Tanjung Jabung Barat District, Jambi) J. Ilmu Pertan. Indone. 22 115–26
[7] Zulkifli Yusop 1, Chong Meng Hui 2, Geoffrey James Garusu 3, A K 1 2008 Estimation Of Evapotranspiration In Oil Palm Catchments By Short-Time Period Water-Budget Method Malaysian J. Civ. Eng. 20 160–74
[8] Pacheco P 2012 Oil palm in Indonesia linked to trade and investment: Implications for forests
[9] Bayu 2018 Perebutan Ruang Kehidupan dan Gangguan terhadap Animal Rights J. Multidisipliner Mhs. Indone. 1
[10] Perkebunan D 2019 Volume produksi kelapa sawit (CPO), 2000-2018
[11] Corley R H V 2009 How much palm oil do we need? Environ. Sci. Policy 12 134–9
[12] Jason Potts, Matthew Lynch, Ann Wilkings, Gabriel Huppé, Maxine Cunningham V V 2014 The State of Sustainability Initiatives Review 2014 vol 10
[13] Vijay V, Pimm S L, Jenkins C N and Smith S J 2016 Dampak Oil Palm pada Deforestasi Terbaru dan Hilangnya Keanekaragaman Hayati Abstrak PLoS One 1–19
[14] Schmidt J H and Weidema B P 2008 Shift in the marginal supply of vegetable oil Int. J. Life Cycle Assess. 13 235–9
[15] Dong N T, Tap V H, Mai N T P and Lien N T H 2020 Estimation of forest carbon stocks in be national park, Vietnam For. Soc. 4 195–208
[16] Wright A 2014 Dampak Sosial Ekonomi Minyak Sawit dan Biodiesel : The Case of Indonesia
[17] Petrenko C, Paltseva J and Searle S 2016 Ecological impacts of palm oil expansion in Indonesia | International Council on Clean Transportation 1–21
[18] Pittman A M, Carlson K, Curran L M and Gonzalez A P 2013 NASA Satellite Data Used to Study the Impact of Oil Palm Expansion across Indonesian Borneo Earth Obs. 25 12–5
[19] Gunarso P, Hartoyo M E, Agus F and Killeen T J 2013 Oil Palm and Land Use Change in Indonesia, Malaysia and Papua New Guinea Reports from Tech. Panels RSPOs 2nd Greenh. Gas Work. Gr. 29–64
[20] Obidzinski K, Andriani R, Komarudin H and Andrianto A 2012 Environmental and social impacts of oil palm plantations and their implications for biofuel production in Indonesia Ecol. Soc. 17
[21] Teh C B S 2016 Availability, use, and removal of oil palm biomass in Indonesia Rep. Prep.
Int. Counc. Clean Transp. 1–39
[22] Eko Rusdianto 2019 Nesatapa Warga Kala Hidup di Kelilingi Kebun Sawit Mongabay situs Ber. Lingkung.
[23] Koh L P and Wilcove D S 2008 Is oil palm agriculture really destroying tropical biodiversity? Conserv. Lett. 1 60–4
[24] Yaap B, Struebig M J, Paoli G and Koh L P 2010 Mitigating the biodiversity impacts of oil palm development CAB Rev. Perspect. Agric. Vet. Sci. Nutr. Nat. Resour. 5 1–11
[25] Yaghoob Jafari 1 *, jamal Othman 2 P W 1 dan S J 3 * 2017 Risiko dan peluang dari imporit utama mendorong keberlanjutan : kasus minyak sawit Indonesia Ekon. Pertan. dan Makanan
[26] Hezri A A 2017 Journal of Oil Palm , Environment & Health An official publication of the Malaysian Palm Oil Council ( MPOC ) REDEFINING SUSTAINABLE An official publication of the Malaysian Palm Oil Council ( MPOC ) Journal of Oil Palm , Environment & Health REDEFINING S
[27] Fitzherbert E B, Struebig M J, Morel A, Danielsen F, Brühl C A, Donald P F and Phalan B 2008 How will oil palm expansion affect biodiversity? Trends Ecol. Evol. 23 538–45
[28] Peh K S H, Sodhi N S, De Jong J, Sekercioglu C H, Yap C A M and Lim S L H 2006 Conservation value of degraded habitats for forest birds in southern Peninsular Malaysia Divers. Distrib. 12 572–81
[29] Danielsen F, Beukema H, Burgess N D, Parish F, BrÜhl C A, Donald P F, Murdiyarso D, Phalan B, Reijnders L, Struebig M and Fitzherbert E B 2009 Plantaciones de biocombustible en terrenos boscosos: Doble peligro para la biodiversidad y el clima Conserv. Biol. 23 348–58
[30] Larsen T H, Williams N M and Kremen C 2005 Extinction order and altered community structure rapidly disrupt ecosystem functioning Ecol. Lett. 8 538–47
[31] Senior M J M, Hamer K C, Bottrell S, Edwards D P, Fayle T M, Lucey J M, Mayhew P J, Newton R, Peh K S H, Sheldon F H, Stewart C, Styring A R, Thom M D F, Woodcock P and Hill J K 2013 Trait-dependent declines of species following conversion of rain forest to oil palm plantations Biodivers. Conserv. 22 253–68
[32] Don A, Schumacher J and Freibauer A 2011 Impact of tropical land-use change on soil organic carbon stocks - a meta-analysis Glob. Chang. Biol. 17 1658–70
[33] Joseph Fargione, Jason Hill, David Tilman S P and P H 2008 Land Clearing and the Biofuel Carbon Debt Science (80-). 319 1235–9
[34] Mubekti M 2016 Estimasi Jejak Karbon Industri Minyak Kelapa Sawit J. Teknol. Lingkung. 15 35
[35] Marty S 2008 Losing Ground
[36] Kallarackal J, Jeyakumar P and George S 2004 Water use of irrigated oil palm at three different arid locations in Peninsular India. J. Oil Palm ... 16 45–53
[37] Taufiq M, Siswoyo H and Wws A 2013 Terhadap Keseimbangan Air Hutan ( Studi Kasus Sub Das Landak , Das Kapuas ) J. Teknik Pengair. 4 47–52