Impact of oil palm plantation on herpetofauna species diversity at PT Waimusi Agroindah South Sumatera

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Abstract. Oil palm plantation playing an important role in Indonesia’s economic development, whereas generates the largest foreign exchange and boosts communities’ economic sector, also absorbs the workforce. However, there are some accusation to oil palm plantation that it caused biodiversity decreased in the minimum of 60%. The study was done to identify the impact of oil palm plantations on herpetofauna diversity, community similarity and percentage loss or gain of community. The observation was done using Visual Encounter Survey (VES) method in the 6 land cover types which classified into 2 land areas. Rubber plantation and shrubs were considered as the land cover before the oil palm plantation establishment. While, young, intermediate, old oil palm plantation and high conservation value forest were considered as the land covers after the plantation establishment. The study was conducted in May 2017 in the South Sumatera Province. The data analysis showed that old palm plantation had a higher species number (19 species) compared to rubber plantation (11 species) and shrubs land cover (3 species). However, rubber plantation and old oil palm plantation had the highest species composition similarity (IS= 0.62). While the lowest happened in both shrubs-old oil palm plantation and shrubs-conservation area (IS= 0.19). The transformation land cover into oil palm plantations led to the gain of herpetofauna species as many as 8 species for rubber plantation and 17 species for shrub, while on the other hand only cause loss of 1 species from shrub and no one species loss for rubber plantation.

1. Introduction
Oil palm plantation playing an important role in Indonesia’s economic development, whereas generates the largest foreign exchange and boosts communities’ economic sector, also absorbs workforce [1]. Besides having a positive impact on the economy, the expansion of oil palm plantations also has a negative impact on ecological aspects. Up to 2017, the area of oil palm plantations in Indonesia reached 12.31 million ha [2]. This makes many negative allegations about oil palm plantations such as increasing carbon emissions, climate and deforestation, thus disrupting environmental balance [3].

One animal that is susceptible to environmental changes is herpetofauna, especially amphibians. Because herpetofauna is poikilotherm animals whose body temperature is strongly influenced by the environment [4]. Also, amphibians also have semi-permeable skin and 2 phases of the life cycle [5]. Herpetofauna has an important role in human life such as predators of insect species that can become disease vectors, Environmental bioindicators and climate change [6], food and export commodities [7].
In Indonesia, herpetofauna is currently not widely known, both regarding taxonomy, biological and ecological characteristics [4]. Similar to herpetofauna studies on oil palm plantations which are also still rare. This makes it important to research the impact of oil palm plantations on the diversity of herpetofauna species. The purpose of this study was to identify the impact of oil palm plantations on herpetofauna diversity, community similarity and percentage loss or gain of community.

2. Materials and Methods
The impact of oil palm plantation on species diversity and composition is the difference between species diversity and composition in the baseline (before the existence of the oil palm plantation land cover) and after the oil palm plantation. In determining the type of land cover before plantations established, Landsat imagery used 2 years before the plantations established. Based on the results of the interpretation, it was found that the dominating area was rubber plantation and shrubs.

2.1. Study Area
Data collection was conducted out in May 2017 at PT Waimusi Agroindah, South Sumatra province. There are 2 categories of land cover. The first is the land before oil palm plantations established (rubber plantation and shrubs), the second is land cover after of oil palm plantation established which are young growth (2012), intermediate growth (2006), old growth (2001) and High Conservation Value area.

2.2. Study Method
The observation of herpetofauna used VES (Visual Encounter Survey) method. Starting from 7.00 p.m-9.00 p.m with 3 repetitions. The observation was made simultaneously on 6 land covers.

2.3. Data Analysis
To find out the impact of oil palm plantation on herpetofauna species diversity, the calculation of some species, evenness index and species richness index are calculated as follows [8]:

- **Species richness index (Dmg)**
  Margalef Index (species richness) used to determine the species richness of each species in the community that found in the field, the formula is:
  \[ Dmg = S - 1 / \ln N \]
  Information:
  \[ Dmg \] = species richness index
  \[ S \] = number of types
  \[ N \] = total number of individuals of all species

- **Evenness index (E)**
  Evenness Index has a function to determine the evenness of each type in every community.
  \[ E = H' / \ln (S) \]
  Information:
  \[ E \] = evenness index (a value between 0-10)
  \[ H' \] = diversity
  \[ \ln \] = natural logarithm
  \[ S \] = Number of types

Whereas to determine the impact of oil palm plantation on species composition, a number of herpetofauna diversity loss and gain in PT Waimusi Agroindah, the following formula is used:

- **Similarity index**
  Similarity index is used to determine the similarity between the observation location based on the type herpetofauna found.
  \[ IS = 2c \frac{1}{a+b} \]
Information:
IS = similarity index
a = the number of species that are only found in community A
b = the number of species that are only found in community B
c = the number of species found in community A and B

3. Results and Discussion
There were 20 species of herpetofauna (12 amphibians and 8 reptiles) with a total of 126 individuals which were successful at the observation site. Table 1 presents a list of the species of herpetofauna found before and after the oil palm plantation established.

Table 1. Variation of herpetofauna in the different type of land cover

| No | Scientific Name          | Family            | Before RP | SH | YG | IG | OG | HCV | OPP |
|----|--------------------------|-------------------|-----------|----|----|----|----|-----|-----|
| 1  | Duttaphrynus melanostictus | Bufonidae         | 0         | 0  | 0  | 0  | 4  | 0   | 4   |
| 2  | Hylarana erythræa        | Ranidae           | 4         | 0  | 1  | 3  | 5  | 5   | 14  |
| 3  | Pulchra pulchra glandulosa | Ranidae          | 0         | 0  | 1  | 0  | 5  | 0   | 6   |
| 4  | Amnomira nicobarizenisis | Ranidae           | 1         | 0  | 0  | 0  | 3  | 0   | 3   |
| 5  | Fejervarya cancrivora    | Dicroglossidae    | 3         | 3  | 10 | 2  | 4  | 8   | 24  |
| 6  | Fejervarya limnocharis   | Dicroglossidae    | 2         | 3  | 9  | 3  | 3  | 6   | 21  |
| 7  | Pulchra baramica         | Ranidae           | 0         | 0  | 0  | 3  | 1  | 0   | 4   |
| 8  | Chalcodorus chalcomotus  | Ranidae           | 0         | 0  | 0  | 0  | 2  | 0   | 2   |
| 9  | Polyedriades leuconymus  | Rhacophoridae     | 0         | 0  | 1  | 0  | 3  | 2   | 6   |
| 10 | Ingerophrynus biporcatus | Bufonidae         | 1         | 0  | 0  | 4  | 1  | 0   | 5   |
| 11 | Limnonectes paracronodon | Dicroglossidae    | 1         | 0  | 0  | 0  | 0  | 1   | 1   |
| 12 | Leptobrachium hasseltii  | Megophryidae      | 0         | 0  | 0  | 2  | 0  | 0   | 2   |
| 13 | Naja sumatrana           | Elipidae          | 0         | 0  | 0  | 0  | 1  | 0   | 1   |
| 14 | Dendrelaphis pictus      | Colubridae        | 1         | 0  | 0  | 0  | 2  | 0   | 2   |
| 15 | Hemidactylus frenatus    | Gekkonidae        | 1         | 0  | 1  | 0  | 0  | 0   | 1   |
| 16 | Latropsis multifasciata  | Scinidae          | 2         | 0  | 0  | 0  | 1  | 1   | 2   |
| 17 | Takydromus sexlineatus   | Lacertidae        | 1         | 0  | 0  | 0  | 0  | 1   | 1   |
| 18 | Bunogus candidus         | Elipidae          | 1         | 0  | 0  | 0  | 1  | 0   | 1   |
| 19 | Bunogus spicatus         | Elipidae          | 1         | 0  | 0  | 0  | 1  | 0   | 1   |
| 20 | Xenochropis vitattus     | Natricidae        | 0         | 1  | 0  | 0  | 0  | 0   | 0   |

Number of Individuals: Before 18 7 23 17 37 24 101

Where: RP=Rubber plantation; SH=Shrub; YG=Young growth oil palm; IG=Intermediate growth oil palm; OG=Old growth oil palm; HCV=High Conservation Value area; OPP=Oil palm plantation

The number of species in the rubber plantation area (11 species) was higher compared to the number of species in the OPP, except for the old oil palm area (15 species). Similar to the research of [8] in one of the oil palm plantations in North Sumatra Province which also found that the RP area had a greater number of species than the SH area, except the OG area. However, other research that was done in West Kalimantan found that the RP had the lowest number of species than OPP [9].

Several factors influence the difference in the number of species. Canopy cover is one of the most influential factors in the presence of herpetofauna at PT Waimusi Agroindah (WMA). This can be seen in figure 1, where the area of SH that has no canopy cover has the lowest number of species and species richness index. It the same case with YG and IG areas which have a lower number and species richness index than the RP area. Based on the results of [10] research, herpetofauna was not found in habitats that have open canopy cover, even though they have adequate sources of food and water.
Unlike the HCV area, even though it has a denser canopy cover with more diverse vegetation, the HCV area has a lower number of species compared to the RP area. This is because the HCV area has many predators for herpetofauna. The results of the study showed that in the HCV area there were 4 species of mammals and 33 species of birds. This amount is the highest number among 5 other land cover. One species of mammal that dominates in the HCV area is long-tailed macaque or *Macaca fascicularis* (28 individuals). The results of the study of *M. fascicularis* in Papua New Guinea by [11] found that the presence of *M. fascicularis* had a very large negative effect on the abundance of herpetofauna. [12] explained that although the main feed of *M. fascicularis* is in the form of fruits, *M. fascicularis* is also an opportunistic omnivore animal which means it can eat various types of food if there is an opportunity. Meanwhile, bird species that dominate in the HCV area include *Indus Haliastur, Acridotheres javanicus, Alcedo coerulescens, Alcedo meninting, Pelargopsis capensis, Ardea cinerea* and *Amaurornis phoenicurus*. [13] state that the main predators of amphibians are birds. According to [14] family of Accipitridae is a carnivorous animal that likes to eat small birds, snakes and fish [15] also explained that eagle feed is snakes, frogs, lizards and small mammals.

![Figure 1](image.png)

**Figure 1.** Comparison of the number of species, species richness and evenness index at type of land cover

Based on Figure 1, it can be seen that the area of OG area has the highest number of species among the 5 other types of land cover. Besides the denser canopy cover factors, the OG area has more water sources than the RP area. Also, the water in the RP area is not permanent and dependent on rainfall, while the water source in the OG area is a canal where the water is permanent and does not depend on rainfall. Research [16] found that the number of amphibians in habitats whose water volume depends on the weather is lowest than habitats whose water sources do not depend on the weather. Amphibians are very dependent on the presence of water sources because amphibians have two life cycles where one cycle requires water as a breeding medium or habitat [17]. Besides being a breeding ground, water sources are also used as a place to protect themselves from drought. Herpetofauna is a species of poikilotherm whose body temperature follows the environment temperature [18].

In addition to having the highest number of species, the OG area has the highest species richness than the baseline area (RP and SH). According to [8] species richness index is used to determine species richness each community encountered. Unlike the case with the species evenness index, the area with the highest evenness index value is the IG area, while the lowest evenness value is found in the YG area. The species evenness index is used to describe the stability of a community [19].

When compared as a whole, the OPP area has a higher number of species and species richness index than RP and SH areas (figure 2). Factors that cause a high number of species and types of wealth in the OPP area because in the OPP area have a lot of water sources and dense canopy cover. The RP area has
a lower number of species than the OPP area because in the RP area there are fewer water sources than the OPP area. Water is needed by herpetofauna, especially amphibians to reproduce [20].

![Figure 2](image-url)

**Figure 2.** The impact of oil palm plantation on herpetofauna species diversity

Similarly, the SH area also has a lower number of species and species wealth than the OPP area. There are only 3 species of herpetofauna found in this area. [21] in oil palm plantations in Riau Province and [22] in Central Kalimantan Province found the same thing, namely the SH area had a lower number of species than the OPP area. Like an RP area, the lower number of species in the SH area is also influenced by canopy cover. According to [23], that canopy cover is one of the factors that affect the species richness and abundance of amphibian species. [24] explained that canopy cover affects the temperature and humidity of a habitat.

![Figure 3](image-url)

**Figure 3.** Comparison of Sorensen similarity index between each oil palm plantation land cover with the baseline

Based on figure 3, it can be seen the value of similarity between the areas before and after the oil palm plantations established. Overall, the value of species similarity in PT WMA tends to be influenced by canopy cover. This can be seen from the similarity value in the OPP area with the RP area which has the highest value in the HCV area and the lowest value in the YG area. It is the same as the comparison of species similarity in the OPP area with shrubs. The highest similarity value was found in the area of YG-SH and IG-SH which had more open canopy cover than the OG and HCV areas. [21] states that habitats that have dense canopy cover have a higher reptile species richness than habitats that have open canopy cover.
The results of the analysis of loss and gain species found in figure 4 show changes in rubber plantations to oil palm plantations resulted in 64% of species gain and did not result in species loss. If compared to each land cover, the area that has the highest number of species loss is the IG area with a value of 64%. This is due to differences in canopy cover and ground cover. Besides having canopy cover which is more open than rubber plantations, the ground cover floor in the IG area is the least vegetation than the other areas. Both of these factors greatly influence the presence of herpetofauna because these factors affect the humidity in the place. Meanwhile, the area with the lowest number of loss species is the OG area (27%).

![Figure 4.](image)

**Figure 4.** Comparison of herpetofauna species loss and gain percentage from a rubber plantation

Species loss due to land conversion from shrubs to oil palm plantations is 33%, and species gain is 533% (Figure 5). The difference is caused because of significant differences in habitat conditions between OPP and SH area. The OPP area has a dense canopy cover, while the SH area has no canopy cover. The highest species gain is found in OG areas which have a gain of up to 400%. Losses species in each type have the same value of 33%. The only species found in the SH area and not found in the RP area or OPP is *Xenochropis vittatus*.

![Figure 5.](image)

**Figure 5.** Comparison of herpetofauna species loss and gain percentage from shrub

In Table 2, it can be seen that there are 8 species of herpetofauna that are increasing and there are no species of herpetofauna lost due to conversion from RP to OPP area. Unlike the case with the conversion from SH to OPP area. There are one species of reptile loss due, but there are 17 species of herpetofauna that have increased due to this conversion. This is because the OPP area has canopy cover and ground cover is denser and has enough water sources. [25] which states that many herpetofauna is found in canopy cover conditions which are denser because they cause the habitat to become moist.
Species that can be found in the RP and SH areas are those that have high adaptation, such as green paddy frog or *Hylarana erythraea*. [26] study was conducted in oil palm plantations and found *H. erythraea* become the dominant species and can be found in all lines of observation. It was also stated by [27] that *H. erythraea* has a high tolerance for interference and has a wide distribution on the Indonesian islands.

Table 2. List of species of herpetofauna that are lost and gained

| Rubber Plantation | Shrub |
|-------------------|-------|
| **Loss** | **Gain** | **Loss** | **Gain** |
| - | *Duttaphrynus melanostictus* | *Xenochrophis vitattus* | *Duttaphrynus melanostictus* |
| *Pulchrana glandulosa* | *Hylarana erythraea* |
| *Pulchrana baramica* | *Pulchrana glandulosa* |
| *Chalcorana chalconota* | *Amnirana nicobariensis* |
| *Polypedates leucomystax* | *Polychrana baramica* |
| *Leptobrachium hasseltii* | *Chalcorana chalconota* |
| *Naja sumatrana* | *Polypedates leucomystax* |
| *Bungarus candidus* | *Ingerophrynus biporcatus* |
| *Limnonectes paramacron* | *Leptobrachium hasseltii* |
| *Naja sumatrana* | |
| *Dendrelaphis pictus* | |
| *Hemidactylus frenatus* | |
| *Eutropis multifasciata* | |
| *Takydromus sexlineatus* | |
| *Bungarus candidus* | |
| *Bungarus pasciatus* | |

In addition, *Fejervarya cancrivora* and *Fejervarya limnocharis* are also species of amphibians that have high adaptability. This can be proven by the 2 amphibians that can be found in all observation areas, including the Shrub (SH) area which does not have canopy cover. As well as the research of [28] who said that *F. limnocharis* has a high adaptation because it can be found in all seasons. [29] stated that this frog could live in extreme environmental conditions.

One species only found in the SH area is *Xenocrophis vitattus*. This snake can be found in several places on the island of Sumatra, Java [30] and the eastern part of Sulawesi [31]. [32] states that *X. Vitattus* or striped keelback is a snake that lives in water and preys on fish. This is following the condition of the SH area, which is home to several species of fish such as *Clarias nieuhofii*, *Mystus sp*, *Channa striata* and *Channa pleurophalma*.

4. Conclusion

The transformation land cover into oil palm plantations increases herpetofauna species diversity. The existence of oil palm plantations has an impact on differences in herpetofauna species composition (Rubber Plantation=38%; shrub=81%). The transformation land cover into oil palm plantations led to the gain of herpetofauna species as many as 8 species for rubber plantation and 17 species for shrub, while on the other hand only cause loss of one species from shrub and no one species loss for rubber plantation.

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