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Assessment and Mapping of Tradeoffs Land Uses in the Orangutan Habitat: A Case *Pongo Pygmeus Pygmeus* Habitat of West Kalimantan

P. G. Siregar[1, a)], J. Supriatna[2], R. H. Koestoer[1], and D. Harmantyo[3]

[1]*Program Study of Environmental Study, Multidisciplinary Graduate Program, Universitas Indonesia, Jl. Salemba Raya No. 4, Jakarta 10430, Indonesia*
[2]*Department of Biology, Faculty of Mathematics and Natural Sciences (FMIPA) Universitas Indonesia, Depok 16424, Indonesia*
[3]*Department Geography, Faculty of Mathematics and Natural Sciences (FMIPA) Universitas Indonesia, Depok 16424, Indonesia*

[a)] Corresponding author: pahrian@gmail.com

Abstract. This study aims to analyse trade-offs among 6 (six) types of dominant land uses to consider Orangutan livelihood and landscape sustainability. The results of this study assists landscape's planners and policy makers for selecting development scenarios as well as policy within the landscape, especially to reduce human and wildlife conflict as impact of development. This study was conducted in Orangutan sub species *Pongo pygmeus pygmeus* habitat in West Kalimantan, Indonesia. Net present value analysis was applied to identify economic profit of land uses and also perspective of expert judgment was applied to identify suitability of the land uses to Orangutan livelihood. The study shows that palm oil plantation was the dominant land use type in non-forest area category and natural forest is in forest area category within the site. Palm oil contributed highest economic profit (average IDR 11 Million per year) compared to other land use types, and thus the worst land use type for supporting Orangutan conservation; index suitability for Orangutan achieved only 21.8. The development of agroforestry which planted more than 3 valuable economic commodities is used as an alternative in forest buffer area development that can provide better gain for economic and Orangutan conservation with index suitability for Orangutan was 43.5. In achieving sustainability at the landscape level, it needs to consider the sustainability of the umbrella species, such as Orangutan. The existence of the umbrella species would also protect other biodiversity, forest and its environmental services.

INTRODUCTION

There has been a decline of Borneo Orangutans (*Pongo pygmeus*) of approximately 64 % during the period of 1970 to 2010 or in the last 50 years and further 22 % decline to occur between 2010 and 2025 [1], mainly due to the human development activities. This situation made Borneo Orangutan is currently critically endangered referring to the mammal's IUCN Red List and listed on Appendix 1 by CITES. The main reasons are destruction, degradation and fragmentation of their habitats. Nonetheless, conversion of forest as Orangutan's habitat do not only have negative effects, as some changes are related to positive increase of food and fibre yields for peoples' health and wealth [2]. Deforestation also contributes to job creations [3] and economic growth [4]. This article asks: "how are trade-offs situation among 6 (six) types of dominant land uses to consider Orangutan livelihood and landscape sustainability". Moreover, it also aimed to identify better development scenarios as well as land use policy to reduce human and wildlife conflict as impact of development.

It is a difficult to realize win-win solution between conserve biodiversity and promote human well-being. Trade-offs and the hard choices they entail are the norm [5]. During earlier stage of development in Kalimantan between 1970 and 1990, Orangutan's habitat was threatened by logging activity. Then, since end of 1990's, the conversion of forest for palm oil (*Elaeis guineensis*) plantation has been threatening Orangutan. This situation is driven by a robust

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global market for palm oil as edible oil and biofuel [6]. Under the current scenario of rapid human population increase, it is a challenge how to achieve efficient and productive agricultural land use while conserving biodiversity. There is a debate whether land for nature and for production should be segregated (land sparing) or integrated on the same land (land sharing, wildlife-friendly farming) [7]. These recent literature largely discussed about the drivers of habitat conversion or human-wildlife conflicts but there is a minimum attention on how trade-offs analysis of land utilization in wildlife habitat, such as: Orangutan, which will help to provide relevant information for decisions.

Trade-offs occurs in development when two or more conflicting objectives are being pursued in a situation where resources are limited, and result in a specific negative outcome being exchanged for another positive outcome in time and/ or space [8]. Trade-offs exists if components of a system are competing with or exclusive of each other. In this sense trade-offs decisions are contrary to win-win situations, but actually, we usually faces a win-lose situation. It implies a decision to be made with full comprehension of both the upside and downside of a particular choice. Trade-offs analysis helps to provide relevant information for decisions and environmental management decisions are matters of societal choice, both are expressions of preference, values and understanding, and need to be discussed, made and justified openly as public judgments [9].

METHODS

It is so difficult to monitor and manage every aspect of biodiversity. Several shortcuts have been used to protect single species, such: umbrella a species. Protecting umbrella species with large tracts of habitat will automatically save many other species [10]. In Kalimantan, Orangutan used as an umbrella species and is a charismatic, arboreal primate that depends on the lowland rainforests and peat forests. Orangutan plays crucial role in the forests. They are excellent as seed dispersers and responsible in part for maintaining forested ecosystems due to their diet of fruits and mobility. Some important environmental services to humanity, from water resources to climate regulation are also provided by Orangutan [11].

The case study was conducted in areas of Orangutan sub species *Pongo pygmeus pygmeus*'s habitat in West Kalimantan, Indonesia. This location was chosen as case study for: (i) the largest Orangutan habitat converted to development purposes in Indonesia; (ii) as an important catchment area of Kapuas River system with approximately 3 million people depend their livelihood on this river system; (iii) as a part of Hearth of Borneo which identified as important forest area for the island. This habitat located in the western part of the Kalimantan's island, lies between north of the Kapuas River up to Sarawak and the east bounded by Schwaner Mountains [11]. The total area of the habitat is approximately 61,674 square kilometers. It is precisely traversed by the Equator with a tropical climate, high temperature and high humidity. This region is a lowland landscapes traversed by the flow path of large and small rivers.

This study observed six land use types, i.e.: rubber plantation, palm oil plantation, agroforestry, forest plantations (both industrial as well as community based forest plantation), *ladang*/upland rain fed, and timber concession. The economics, the concept of trade offs is fundamental. It derives from the idea of resource scarcity. An individual or society collectively must give up some amount of another scarce good; in this study we used economic profit and Orangutan conservation [12]. Trade-offs analysis in this study consists of identification economic profit of land uses and identification of land use suitability to Orangutan. Data collection was undertaken from September 2015 to April 2016. Focus group discussions, key informant interviews, and semi-structured interviews were conducted with community member and leaders to get information about agriculture activities. Information about statistical data on agricultural production and forestry business activities were collected through desk study.

Economic profit analysis was conducted through calculating the net present value per year (NPV/ year) of each land use type, using a 7 % per year discount rate (the interest rate or the inflation rate predicted applies). In each type of land use, we identified the maximum and minimum economic profit's scenario. A set of questionnaire was distributed to Orangutan experts on vulnerability assessments of land use on Orangutan conservation from March to April 2016. Ratings given by experts were including: vulnerability to trigging forest fire, potential as trigger of fragmented the existing habitat, availability of food and nest trees for Orangutan, the potential location for poaching, the potential for use as a corridor or crossing, and the potential of increased human and Orangutan conflict.

RESULTS AND DISCUSSION

Identification Economic Profit of Land Use

The results of the economic profit per year based on the calculation of net present value per year, investment needs, and the length of negative cash flow as well as business cycles period of each land use observed in this study are shown in Table 1. Land use activity that produced the highest economic profits per year is palm oil plantation (IDR 10 up to 12 M/ha/year), but requires high investment (IDR 41 up to 48 M/ha/year). High profit generated from palm oil plantation attracted many multinational companies to invest in this business. Palm oil plantation's cash flow is negative for the first three years; this situation made landowners should have large reserve fund or other income to survive in the business. The similar situation is also applied in rubber plantation, although the investment needed is smaller (IDR 16 up to 21 M/ha/year) and the potential profit is less than palm oil plantation (IDR 2 to 3 M/ha/year). In many locations, the presence of alternative financial institutions, such as: credit union, greatly helped landowners to be able to invest in palm oil or rubber plantations through loan schemes.

Ladang/ upland rainfed is land use activity that require minimum investment (IDR 4 up to 8 M/ha/year), despite the profit is also not too high (only IDR 2 up to 7 M/ha/year) and usually rice are consumed by the landowner. Limited and/or less access to capital caused landowners maintain their lands into *ladang*, while saving or seeking access to loans. Landowners were then planted land with perennial or tree crops, such as: fruit tree in their *ladang*. When *ladang* are overgrown with tree crops that provide economic profits to their owners, then this land will be no longer used as *ladang* and transformed into agroforestry. Meanwhile, agroforestry requires low investment (IDR 6 up to 7 M/ha/year) and mostly invested gradually. In agroforestry where planted with more than three economic commodities, the potential annual profit would be quite higher (IDR 7 up to 10 M/ha/year).

In the forestry sector, the investment for timber plantations, both industrial and community based, are quite high (IDR 64 up to 82 M/ha/year) and seem very difficult to run by limited capital landowners, such as local communities nearby the forest. While, the profit per hectare produced by timber plantations is only IDR 400 up to 900 thousand/ha/year. However, due to large concessionaire area were given to the investor, the investment can achieve the economics of scale. Contrarily, despite the investment requires for timber concession is not too high (IDR 5.55 M/ha) and potential profit is also quite high (IDR 6 M/ha/year), it is hard for investors with limited capital, due to the concessions are given in large area, thus requires huge amount of investment.

The distribution of land uses in the observed landscape is presented in Table 2, based on interpretation of 2014's satellite images situation developed by the Ministry of Environment and Forestry (MoEF) and additional interpretation for palm oil plantations based on National Land Agency (NLA) data. Natural forest is the largest land use in the observed landscape, which reached 35 % of the total area. Most of natural forests left in forest area category and only a few are in non-forest area category.

Nevertheless, only few natural forests generated economic benefit, because none of timber concessions still operates in the observed landscape [13]. Meanwhile, timber plantation covered 5 % of the landscape and most of

TABLE 1. Economic Profit per Year of Each Land Use Type

Land Use Type	Investment (IDR/Ha)	Negative Cash-flow (years)	Activity Period (years)	Economic Profit per year (IDR/Ha/year)
Palm Oil Plantation	40,604,236 up to 48,309,092	4	25	10,281,490 up to 12,166,290
Ladang	4,118,000 up to 8,228,000	0	1	2,913,000 up to 6,892,000
Agroforestry	6,000,000 up to 6,500,000	1	30	7,481,667 up to 10,006,667
Rubber Plantation	16,188,827 up to 20,989,024	5	30	1,603,239 up to 2,801,465
Timber concession	5,550,000	0	55	5,889,098
Industrial Forest plantation	82,061,792	8	63	378,433
Community based Forest plantation	63,997,683	8	63	903,973

them were in the middle sub landscape. Palm oil plantations, the most profitable land uses in the observed landscape, covered 15 % of the area and the dominant land use type in non-forest area category. It is estimated that palm oil plantation will be still growing in the future because many areas owned by palm oil plantation companies have not been developed yet.

At a glance, the land utilization was fairly balance in landscape level, but when we observed more in sub landscape level, we found imbalance situation, wherein the upstream sub landscape was dominated by natural forest, which reaches 78 % of the total sub landscape area. While in the middle and the coastal, the remaining natural forests are only 13 % and 20 % of the total sub landscape area. Palm oil plantations are mostly located in the central and coastal areas, which accounted for 24 % of land area in the middle sub landscape and 15 % of land in coastal sub landscape.

Vulnerability Analysis of Land Use for Orangutan Conservation

Tropical natural forest is a natural habitat for Orangutan, although it does not mean it will safe from poaching and forest fires. The finding from the questionnaire depicted medium rate for poaching and forest fires threat in the tropical forest (see Fig. 1a). This situation shows that without adequate security actions, Orangutan populations in natural forests also remain questionable for their sustainability. Increasing access due to road construction could also increase the potential for hunting and forest fires in natural forest. Tropical forest has total composite value of index suitability for Orangutan as high as 63.3 and as the highest among other land uses. Agroforestry assessment result shows lower vulnerability for Orangutan conservation with total composite value of index suitability for Orangutan as high as 43.5, despite the potential conflict between human and Orangutan was in medium rate (see Fig. 1b). Planting fruit in agroforestry could be caused this result, which feared the occurrence of crop raiding by Orangutan.

TABLE 2. Distribution of Land land uses in the observed landscape

Land Use Type	Total Areal		Upstream		Middle		Coastal	
	Ha	%	Ha	%	Ha	%	Ha	%
Natural Forest	2,143,119	35	1,469,018	78	344,490	13	329,611	20
Forest Plantation	294,396	5	0	0	292,832	11	1,564	0
Shrubs	219,568	4	55,764	3	60,325	2	103,479	6
Shrubs in swamp	137,341	2	49,542	3	29,599	1	58,201	4
Dryland Agriculture	212,941	3	140	0	8,939	0	203,862	13
Dryland Mixed Farming	1,864,735	30	160,371	9	1,220,282	46	484,083	30
Palm oil plantation	913,740	15	40,783	2	633,745	24	239,212	15
Others	381,521	6	106,910	6	80,976	3	193,635	12
Grand Total	**6,167,360**		**1,882,527**		**2,671,187**		**1,613,646**	

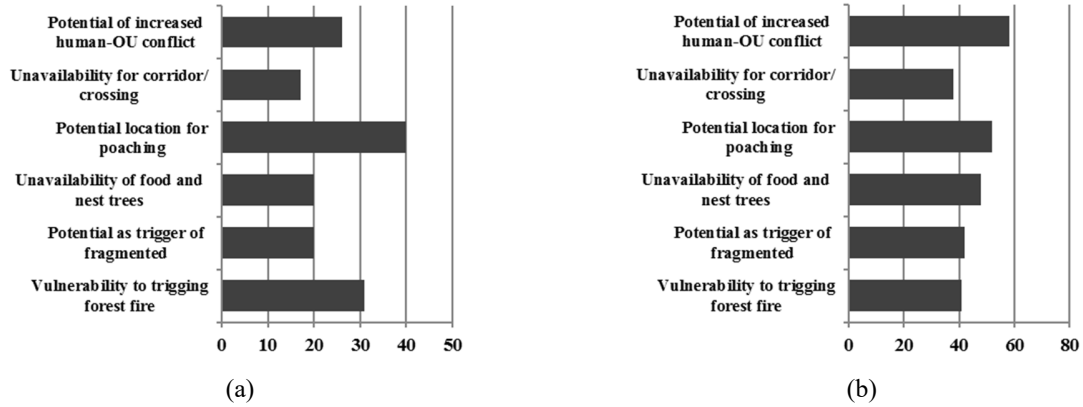

FIGURE 1. Graphics of Orangutan vulnerability assessment for (a) natural forest and (b) agroforestry

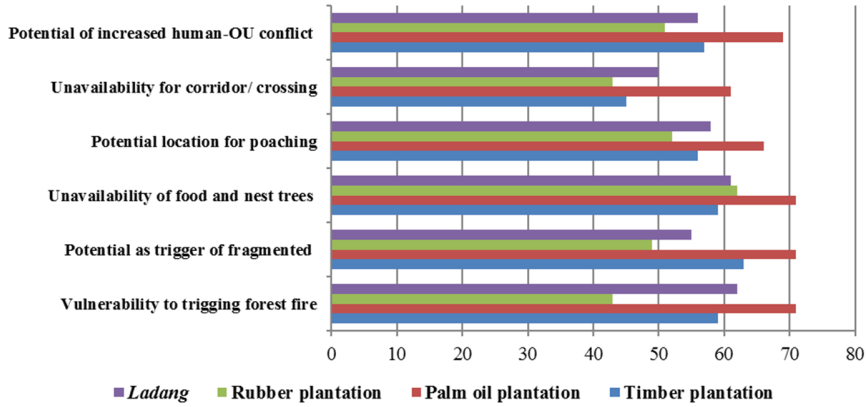

FIGURE 2. Graphics of Orangutan vulnerability assessment for *ladang*, rubber plantation, palm oil plantation and timber plantation

Some fruit planted in community's agroforestry land, such as: durian (*Durio zibethinus*), rambutan (*Nephelium lappaceum*), jengkol (*Archidendron pauciflorum*) and petai (*Parkia speciosa*), were also the favourable fruit for Orangutan. We need to anticipate this potential conflict in the future, especially in the buffer area of Orangutan habitat.

Expert judgments who responded the questionnaire, palm oil plantations, rubber plantations, timber plantation and *ladang* appeared to have high degree of vulnerability for Orangutan conservation (see Fig. 2). Palm oil plantations rated very high vulnerability in all categories in the questionnaire, such as: high potential conflict of human and Orangutan, less possible used for corridor or crossing, high potential location for poaching, less availability of food and nest trees, high potential as triggers of habitat fragmentation and the high vulnerability to trigging forest fire. Palm oil plantation has the lowest total composite value of index suitability for Orangutan as low as 21.8. Meanwhile, *ladang* (33), timber plantation (33.5) and rubber plantation (40) show slightly better total composite value.

Based on composite value of Orangutan vulnerability, we mapped vulnerability conditions at the landscape level (see Fig. 3). It appeared that 35 % of area in high vulnerability, 3 % of area in medium vulnerability, 36 % of area in low to medium vulnerability and 26 % of the area in low vulnerability to Orangutan. Further, at sub landscape level, there was a gap between the vulnerability conditions in upstream, central and coastal sub landscape. The conditions in central and coastal sub landscape were dominated by medium to high vulnerability and high vulnerability, while the upstream was dominated by low vulnerability.

Trade offs Land Uses

We presented the simple way to figure out trade-offs through presenting economic profit and composite Orangutan vulnerability value of each land use into a graph (see Fig. 4). We divide into four quadrants of trade-offs situation. The first quadrant is land uses that have high economic profitability and high suitability for Orangutan conservation. Agroforestry is the only land use which plotted in this quadrant. Meanwhile, logging concession plotted in the transition area between the first and third quadrant. Palm oil plantation plotted in the second quadrant which has high economic profit, but low suitability for Orangutan conservation. The third quadrant provides low economic profit, but high suitability for Orangutan conservation, with rubber plantation and timber concessionaire plotted in this quadrant. Rubber plotted in the transition area between third and fourth quadrant. While timber concessionaire plotted in the transition area between third and first quadrant. The fourth quadrant is the area for the land use that provided low economic profit and also low suitability for Orangutan conservation, industrial timber plantation, community based timber plantation, and *ladang* plotted in this quadrant.

Land allocation for different land use types on landscape is a multi-dimensional problem and influenced by complex process of land use changes. The decision of land utilization is often face a dilemma to twine economic and environmental interests. In reality, it is very difficult to develop win-win solution mechanisms for both policy and

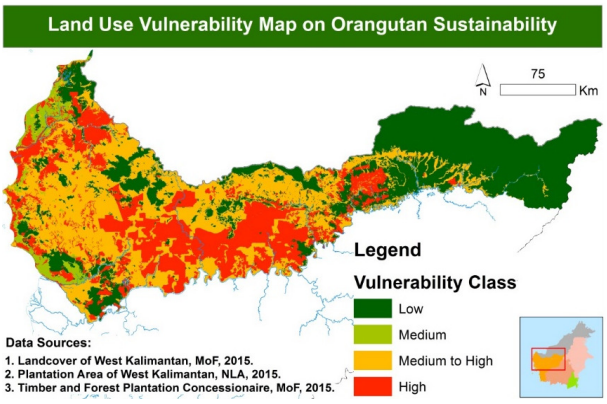

FIGURE 3. Map of land use vulnerability on Orangutan sustainability

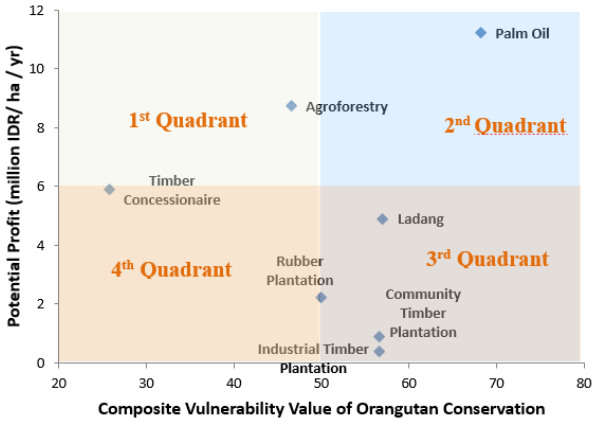

FIGURE 4. Trade-offs economic pprofit and Orangutan sustainability

community level. However, without inadequate knowledge and information, it will lead to false direction in determining the land allocation to be considerably sustainable. Some references suggested trade-offs analysis should become important approach to prioritized and targeting management interventions in multifunctional landscapes [14, 15]. We support this idea and also support the idea to use trade-offs analysis as discussion reference, rather than decision tool, such as where policy makers and landowners use trade-offs analysis to evaluate options and implement an appropriate alternative.

In the global marketplace, palm oil is omnipresent and its utilization has arisen dramatically due to its high production yield. Palm oil is about five to eight times more volume per hectare compare to others oil-crops [16]. The growth in palm oil production is predicted will be continuing because the increment of the demand for food and bio-fuels [17]. In Indonesia, palm oil is the second largest agricultural product which is the dominant estate crop and major contributor to economic development in certain regions, such as observed landscape [18]. The rapid growth of palm oil development in the observed landscape was not only caused by global demand, but also due to the highest economic benefits gain compared to other land uses. Without any significant policy intervention in the future, we aligned with other researchers predicted the development of palm oil in the observed landscape will keep expanding [19]. The desire to obtain economic growth and employment are the main trigger of palm oil extension at present. As we found in this study, palm oil plantation is the most vulnerable land use for Orangutan, like also concluded by other researchers [6, 20]. The increasing of palm oil plantation in observed landscape will continue to threaten the Orangutan sub species *Pongo pygmeus pygmeus* sustainability. It is necessary to change the palm oil development orientation from plantation expansion to intensification and increasing added value of the products.

Agroforestry with more than 3 valuable economic commodities could be an alternative land use to reduce the dominance of palm oil plantations. However, it should be noted fruit based agroforestry in the buffer zone of conservation area or protected forest where also habitat of Orangutan should be avoided to anticipate the humans and Orangutan conflict in the future. Based on some studies in Sumatera, where Orangutan habitats have been isolated by other land uses, they recorded occurrence of crop raiding by Orangutan in agroforestry area [21]. We suggest planting timber crop and reducing fruit crop in the local community agroforestry in buffer zone of Orangutan habitat to minimize human and Orangutan conflict.

CONCLUSIONS

Palm oil plantation is the highest economic profits per year among 6 (six) types of dominant land uses and covered 15 % of the area. It is very difficult to the limited capital landowners to invest in this business due to high investment and longer time to achieve positive cash flow. The similar situation is also applied in rubber plantation with less investment and less potential profit. *Ladang* is the lowest investment, despite the profit is also not too high.

Agroforestry requires low investment, but have quite high potential annual profit. The investment for timber plantation is quite high with low profit per hectare and investment requires for timber concession is not too high with quite high profit. The largest land use in the observed landscape is natural forest, which reached 35% of the total area, and palm oil plantation is the dominant land use in non-forest area category. The land utilization is quite

balance in landscape level, but it is imbalance in sub landscape level, wherein the upstream is dominated by natural forest and the the middle and the coastal are dominated by industrial use, such as palm oil plantations and timber plantation.

Tropical forest has the highest total composite value of index suitability for Orangutan (63.3) and palm oil plantation has the lowest (21.8). Meanwhile, rubber plantations (40), timber plantation (33.5) and *ladang* (33) appeared to have high degree of vulnerability for Orangutan conservation. Agroforestry assessment result showed lower vulnerability for Orangutan conservation with total composite value of index suitability for Orangutan as high as 43.5. Based on vulnerability map conditions in the observed landscape, it appeared that 35 % of area in high vulnerability, 3 % of area in medium vulnerability, 36 % of area in low to medium vulnerability and 26 % of the area in low vulnerability to conserving Orangutan sustainable.

The dominance of palm oil development in the landscape should be avoided, because it will threat to sustainability of the Orangutan and other biodiversity. It is necessary to change the palm oil development orientation from plantation expansion to intensification and increasing added value of the products. Agroforestry where planted more than 3 valuable economic commodities becomes an alternative land use to reduce the dominance of palm oil plantations. However, fruit crop based agroforestry development should not apply to the area where not adjacent to Orangutan habitat for minimizing potential of crop raiding in future.

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