Rapid Expansion of Palm Oil Plantation,Livelihood of Smallholders, and Indirect Deforestation: A Case Study on Dusun Tonggong, Parindu, West Kalimantan, Indonesia

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LIST OF ABBREVIATIONS

ABM	Agent-Based Models
BPS	*Badan Pusat Statistik* / Statistical Agency
CBA	Cost-Benefit Analysis
E-CBA	Extended Cost-Benefit Analysis
GIS	Geographic Information System
ILUC	Indirect Land-use Change
ISPO	Indonesia Sustainable Palm Oil
IPOA	Indonesian Palm Oil Association
NGO	Non-Governmental Organization
NPV	Net Present Value
PTPN	PT Perkebunan Nusantara
RSPO	Roundtable on Sustainable Palm Oil
HCV	High Conservation Value

EXECUTIVE SUMMARY

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Keywords: Palm Oil Plantation, Indirect Deforestation, Smallholder Livelihood Strategy

1. RESEARCH BACKGROUND

The development of the palm oil industry in Indonesia is not only enjoyed by large private/national companies but also by local communities around plantation areas. However, despite benefiting from the development of the palm oil industry, in reality, there are several issues regarding small farmers that need to be concerned. Their participation in the oil palm value chain often has unclear and detrimental requirements, making them vulnerable to manipulation by both parties, companies, and government officials (Cramb, 2013; Gillespie, 2011; McCarthy, 2010).

Several studies that discuss smallholder palm oil plantations and deforestation are generally dominated by discussions of social conflict, causes of deforestation, the rate of deforestation, and the impact of deforestation on biodiversity (Austin et al., 2018; Margono et al., 2014; Hosonuma et al., 2012; Gibbs et al., 2010; McCharty., 2010) or conversely, discussing how palm oil can provide benefit for the local communities (Budiarsono et al., 2013; Feintreine et al., 2010; Hayami, 2010; Wiggins et al., 2010). There has not been much discussion regarding diversification income as an adaptation practice from local farmers to respond to the palm oil expansion

Studies on indirect deforestation are also still limited in the scope of certain commodities and have only reached the stage of showing evidence that indirect deforestation has occurred and its causes (Feintrenie et al., 2010; Arima et al., 2011; Macedo et al., 2012; Nelson et al., 2013; Rausch & Gibbs, 2016; Austin et al., 2017; Gollnow et al., 2018). The study about income diversification in relation to indirect deforestation has not been explored in the previous research. This study tries to specifically discuss how local farmers' decisions in determining their land-use pattern can lead to indirect deforestation and also the potential impact that local farmers in the future may feel if indirect deforestation is allowed to continue.

This study is needed to prevent the unintended consequences of deforestation prevention policies, such as indirect deforestation. In the long term, it can help the small farmers live in harmony with nature while maintaining their well-being. The finding from this study is expected to answer several questions:

1. How can indirect deforestation happen in the context of palm oil expansion?
    a. How is the condition of secondary forests due to indirect deforestation?
    b. What are the factors that caused the local farmers to conduct indirect deforestation?
2. How can the indirect deforestation phenomenon affect the local farmers' future?

2. METHODOLOGY

In general, this study uses a mixed-methods approach with an explanatory design research strategy. This strategy always starts with the collection and analysis of quantitative data in the first stage, followed by the collection and analysis of qualitative data in the second stage, which is built based on the initial results of the quantitative analysis in the first stage.

Specifically, this study uses three types of methodology: geospatial analysis (GIS-Based) to see indirect deforestation, extended cost-benefit analysis to calculate the economic and environmental cost and benefit of palm oil plantation, and Agent-Based Models (ABM) to predict the possibility of land-use change in three scenarios designed based on the agent typology.

3. RESULT

"How is the condition of secondary forests due to indirect deforestation?"; The secondary forest area open due to indirect deforestation has a significant value of 149.16 hectares. Indirect deforestation is the result of the decision of the people in Dusun Tonggong to move their *ladang* to secondary forest areas, as they consider it less profitable than palm oil plantations.

"What are the factors that caused the local farmers to conduct indirect deforestation?"; Based on the calculations in all of the scenarios of Extended Cost Benefit Analysis (ECBA), taking the potential loss of environmental services into account, it is financially feasible to create oil palms in shrublands (land that was originally use for ladang) with mineral soil. They prefer to conduct oil palm plantation because of three main factors: (1) economic, (2) labor force, and (3) land area.

4. DISCUSSION

"How can indirect deforestation happen in the context of palm oil expansion?"; Facing the current expansion of oil palm plantations is challenging for local communities. The people of Dusun Tonggong are one of the local community groups who accept the presence of oil palm plantations. They combine the agriculture system they have built from generation to generation with oil palm plantations. The people of Dusun Tonggong diversify their income, hoping that they will still benefit from including oil palm plantations in the agriculture system. They are well aware of the importance of income diversification based on their experience relying on rubber forests as their source of livelihood. Since the sustainability of a commodity like rubber and palm oil is often influenced by the global political economy, sustainable market demand is uncertain. This can lead to "devastation" if they rely solely on the uncertainty of world markets. As a consequence, the people of Dusun Tonggong decided to move their *ladang* to secondary forest areas

"How can the indirect deforestation phenomenon affect the local farmers' future?"; Diversification of income has negative impact. This may happen if the local people start a palm oil plantation in a land that initially a local plantation (*ladang*) – causing the local plantation has to be move to the outer side of forest. If this continues, the people of Dusun Tonggong will lose all of their secondary forests within the next 40 years. There are efforts to build communal palm oil, Palm oil agroforestry, and replanting palm oil plantations on the same land that can be an alternative to reduce indirect deforestation in the future.

This study shows that indirect deforestation can occur not only due to zero-deforestation commitments but also due to local people's choices to diversify incomes. This can happen by combining new commodities such as oil palm plantations and local agricultural systems such as *ladang*. Such choices are made as a defense for local communities against global market uncertainty, which is always identic with commercial commodities such as palm oil.

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CHAPTER 1. INTRODUCTION

1.1 The Problem

This study discusses the issue of deforestation and smallholder palm oil plantations. The development of the palm oil industry in Indonesia is not only enjoyed by large private/national companies but also by local communities around plantation areas. However, in practice, their participation in the oil palm value chain often has unclear and detrimental requirements, making them vulnerable to manipulation by both parties, companies and government officials (Cramb, 2013; Gillespie, 2011; McCarthy, 2010).

Several studies that discuss smallholder palm oil plantations and deforestation are generally dominated by discussions of social conflict, causes of deforestation, the rate of deforestation, and the impact of deforestation on biodiversity (Austin et al., 2018; Margono et al., 2014; Hosonuma et al., 2012; Gibbs et al., 2010; McCharty., 2010) or conversely, discussing how palm oil can provide benefit for the local communities (Budiarsono et al., 2013; Feintreine et al., 2010; Hayami, 2010; Wiggins et al., 2010). There has not been much discussion regarding diversification income as an adaptation practice from local farmers to respond to the palm oil expansion.

Studies on indirect deforestation are also still limited in the scope of certain commodities and have only reached the stage of showing evidence that indirect deforestation has occurred and its causes (Feintrenie et al., 2010; Arima et al., 2011; Macedo et al., 2012; Nelson et al., 2013; Rausch & Gibbs, 2016; Austin et al., 2017; Gollnow et al., 2018). The study about income diversification in relation to indirect deforestation has not been explored in the previous research. This study tries to specifically discuss how local farmers' decisions in determining their land-use pattern can lead to indirect deforestation and also the potential impact that local farmers in the future may feel if indirect deforestation is allowed to continue. To meet this goal, the conceptual framework on farmer decision-making processes and their interactions with internal and external factors developed by Valbuena et al. (2010) is modified. This conceptual framework sees that decision-making by farmers is always based on internal factors (ability and willingness) as well as external factors (market demand, policy, etc.). The finding of this study is expected to answer two main questions and two sub-question:

1. How can indirect deforestation happen in the context of palm oil expansion?
    a. How is the condition of secondary forests due to indirect deforestation?
    b. What are the factors that caused the local farmers to conduct indirect deforestation?
2. How can the indirect deforestation phenomenon affect the local farmers' future?

1.2 Rapid Development of Smallholder Palm Oil Plantation in Indonesia

Indonesia is a tropical country that is famous for its soil fertility. With large forest areas, logging became one of the biggest sources of economic growth in the 1960s and 1970s (Roberti, 1989). However, with the decreasing amount of forest area due to unsustainable logging, the development of this industry did not last long (Sumiani et al., 2007). It began to shift to agribusiness in the 1980s (Roberti, 1989).

In the 1980s and 1990s, Indonesia experienced rapid economic growth which is known as the "economic miracle," part of which was contributed by the agribusiness sector. Along with the sector's development, at the end of 1990, oil palm plantations in Indonesia also developed. The development of oil palm is expected to help overcome poverty, overpopulation, and unemployment. (Barber, 1998). This reason becomes the justification for the systematic exploitation of natural resources for the benefit of the development process (Barber, 1998).

Currently, the development of oil palm plantations in Indonesia is still ongoing. The oil palm plantations in Indonesia have grown by 13.4 million hectares since 1990. Private plantations and smallholder plantations contribute greatly to the total land area (see **Table 1**).

Table 1 Ownership of Palm Oil Plantation Area in Indonesia (thousands of hectares)

Year	Smallholder plantation	National plantation	Private plantation	Total national area
1990	291.33	372.25	463.09	1,126.67
1995	658.54	404.73	961.72	2,024.99
2000	1,116.76	588.12	2,403.19	4,158.07
2005	2,356.89	529.85	2,567.07	5,453.81
2010	3,387.26	631.52	4,366.62	8,385.4
2015	4,535.40	743.90	5,980.98	11,260.28
2020	6,044.06	565.24	7,977.30	14,586.60

Source: Directorate General of Plantation, Ministry of Agriculture, 2020

The rapid development of oil palm plantations has proven to improve people's welfare. The oil palm plantation industry can absorb 7.3 million direct workers and more than 14 million indirect workers, and oil palm plantations managed by independent smallholders can absorb 4.6 million workers. Overall, the palm oil industry contributed nearly US$25 billion in foreign exchange (Ministry of Agriculture, 2020).

The numbers above look promising in terms of economic aspect. However, it cannot be avoided that the development of the palm oil industry also brings negative impacts not only from the environmental aspect but also from the social and economic aspects. In the environmental context, oil palm plantations contribute to regional deforestation in several areas, peatland draining and burning, biodiversity declines, greenhouse gas emissions, and air pollution (Meijaard et al., 2020; Schoneveld et al., 2019; Meijaard et al., 2018; Dislich et al., 2017; Gaveau et al., 2014; Savilaakso et al., 2014; Foster et al., 2011). Socially and economically, the development of oil palm plantations also has negative effects, both directly and indirectly. The direct negative impacts are often reported as social conflict and land grabbing. Meanwhile, the indirect impact of oil palm plantations is the loss of ecosystem services, which is defined as the loss of benefits provided by nature and ecosystems to human beings (Ayompe et al., 2021; Santika et al., 2019; Cordoba et al., 2019).

1.3 Land-use change and Deforestation in Palm Oil Plantation Development

The term land use was first introduced by Sauer (1919), which is defined as the use to which the entire land surface is put. Land use refers to man's activities that are directly related to the land (Clawson and Stewart, 1965), so the changes can be interpreted as changes in human activities related to land. Since its introduction until now, the term land-use change has been often used by both academics and non-academics as a strategy for managing natural resources and also monitoring environmental changes.

Sauer (1919) classified land use into several groups, including forest cover and cultivated land. The two classifications above are, in fact, almost inseparable. In the agribusiness sector especially, the existence of cultivated land often replaces forest cover (Wicke et al., 2008). The definition of deforestation is very diverse. The term deforestation can be used to describe the total loss of forest cover, loss of a certain proportion of land cover, or loss of land cover in primary forest (Kummer, 1991; Angelsen, 1995; Sunderlin and Resosudarmo, 1996). In

Indonesia, through The Republic of Indonesia Forestry Minister's Regulation number: P.30/Menhut-II/2009, deforestation is defined as a permanent change from a forested area to a non-forested area caused by humans.

The development of oil palm plantations in Indonesia is always related to the issue of deforestation – its rapid and massive growth has a negative impact on the environment, especially in the context of deforestation. As much as 52% to 79% of oil palm plantations in Indonesia are planted in areas that were previously forest areas (Koh et al., 2011; Gunarso et al., 2013; Koh & Wilcove, 2008).

1.4 Indirect Land Use Change and Indirect Deforestation in Palm Oil Development

Land-use change does not come without a cost. Changes in land use from one function to another will have positive and negative impacts (Wu, 2008). There are two types of land-use change: direct land-use change (dLUC) and ILUC. dLUC is defined as a change in land function that occurs on the same land as the land use, while ILUC is defined as a mechanism that affects the area outside the occupied land, regardless of the land use purpose (Schmidt et al., 2015). The land-use change that will be discussed in this study is the change in forest cover driven by changes in land-use patterns due to the arrival of oil palm plantations in the Dusun Tonggong area. The term indirect deforestation is more appropriate to describe, more specifically, the loss of forest cover in this area.

Searchinger et al. (2008) found that in conditions of high demand for biofuel products, restrictions on the production of biofuel raw materials in forest areas encourage the cultivation of biofuel raw materials on existing agricultural land, which leads to the transfer of agricultural land to the new land. This phenomenon was later named by Mathews and Tan (2009) as indirect land-use change (ILUC).

The ILUC concept itself is still relatively new. No-one denies that ILUC are real (Mathes and Tan, 2019). Much research on ILUC itself has been carried out, from understanding the concept and efforts to prevent the occurrence of ILUC, and the dynamics of ILUC, to measuring ILUC and its policy implications (Daioglou et al., 2020; De Sa et al., 2013; Khanna & Cargo, 2012). ILUC can occur not only in the context of forest cover but can also occur on non-productive land, grasslands, or even town sites. However, in reality, the ILUC concept itself is often related to the loss of forest cover or grasslands indirectly as a result of the pressure generated by the high demand for another commodity like palm oil.

The loss of forest covers due to palm oil expansion in non-forest areas causing deforestation by locals in other areas is referred to as indirect deforestation (Gollnow et al., 2018). Indirect deforestation is one of the practices of ILUC, but ILUC itself is not necessarily in the form of indirect deforestation. The term indirect deforestation was first used by Liska and Perrin (2009) in their research to indicate the existence of indirect forest cover changes specifically. This phenomenon has occurred in the Amazon region, Papua New Guinea, Jambi, and several other regions in Indonesia (Arima et al., 2011; Gollnow et al., 2018; Macedo et al., 2012; Nelson et al., 2013).

The use of ILUC and indirect deforestation has implications for the amount of data needed in the analysis (Nelson & Geoghegan, 2002). Land-use change can refer to two processes (Davis et al., 2019). The first process is a change in land cover related to the expansion or contraction of the area of land use for different purposes (pasture, cropland, urban). The second process involves changes to land management in the existing land cover (changes in irrigation, agricultural plant species, or impermeable surfaces). Therefore, the use of indirect deforestation is appropriate to describe the indirect loss of forest cover.

Some of the current oil palm plantations in Indonesia originate from land previously used by local communities to meet their subsistence needs instead local communities shifting their fields to nearby forest areas. Rausch and Gibs (2016) explain that indirect deforestation can occur in the displacement of deforestation between commodities. Like the soybean case shown in Brazil (Gollnow et al., 2018), the Indonesian government's initiative to prohibit clearing oil palm land in forest areas trigger deforestation in other areas. Understanding the concept of indirect deforestation is very important to prevent the occurrence of indirect deforestation in the future.

CHAPTER 2. PALM OIL PLANTATION AND INDIRECT DEFORESTATION: A CAUSAL EFFECT

2.1 Introduction

Studying indirect deforestation in the development of land-use conversion practices is fundamental in preventing changes from forest land to other land uses (non-forest). Partial handling that only on reducing the direct deforestation rate will be dangerous. Understanding the indirect deforestation concept is very important if the Palm Oil Moratorium aims to ban all deforestation from the palm oil supply chain. However, an understanding of indirect deforestation needs to be accompanied by an understanding of how local farmers make decisions regarding their land.

2.2 Local Farmers' Decision-Making, Internal and External factors

Local farmers are dynamic people - they will adapt to developments in their area (Darmanto & Setyowati, 2012). Valbuenal et al (2010) Local farmers are dynamic people - they will adapt to developments in their area (Darmanto & Setyowati, 2012). Valbuenal et al. (2010) build a framework to describe the decision-making process and the factors that influence it externally and internally (see Figure 1). In principle, local farmers' decisions in managing their land are based on environmental, economic, and social conditions. This condition forms internal factors, which consist of the ability and willingness of local farmers (Savari & Shokati, 2021). Ability refers to the conditions owned by local farmers and farms at a particular time for decision-making (Valbuena et al., 2010). In general, the ability is related to spatial location, age, family structure, farm size, labor, soil characteristics, and slope (Siebert et al., 2006). Willingness is related to farmers' values and intentions and how farmers interpret their preferences to choose certain actions (Siebert et al., 2006). Value never changes too often, so it can be assumed that willingness is relatively stable in time (Grube et al., 1994; Rokeach, 1968; Valbuena et al., 2010). Value can also be defined as a particular area's culture (Hribar & Lozej, 2013).

The second factor is the external factor. This factor reflects the interactions between farmers, social networks, and institutions such as local government and markets (Valbuena et al, 2010). The interaction between farmers, institutions, and social networks can be explained as follows: first, institutions related to rural area development can give incentives for farmers to improve their abilities, range of options, and future decisions. This also applies to social networks that can provide advice to farmers (e.g., family and friends), which also affects their willingness for decisions in the future. Second, to influence or avoid some of the actions of farmers, the government usually introduces regulations that can affect the ability of the farmers to manage their land. Finally, the demand for goods and services can determine if the agricultural activities carried out by the communities are profitable or not. The conceptual model from the above explanation can be seen in **Figure 1**.

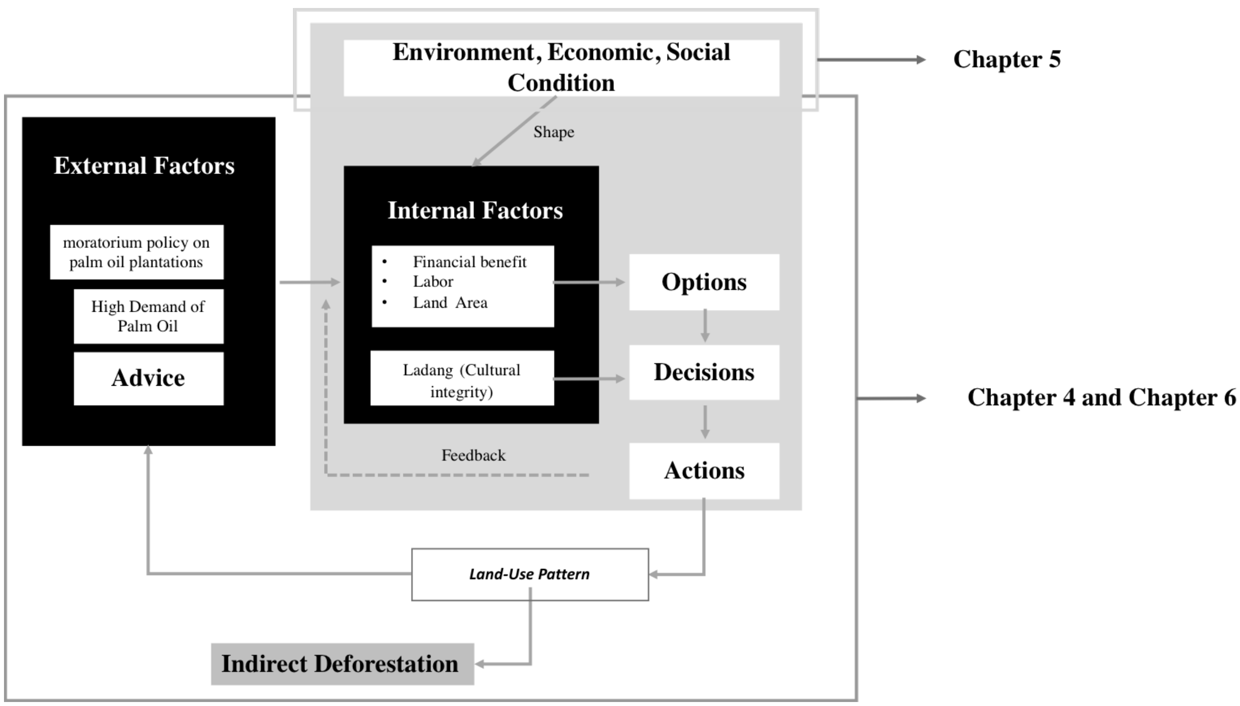


Figure 1. The Conceptual Framework for Farmer Decision-making Processes and Their Interactions with Internal and External Factors (modified from Valbuena et al., 2010)

2.3 The Impact of Palm Oil Regulation on Local Farmers

The fact that the development of palm oil plantations has negative impacts has encouraged multinational retailers, Non-governmental organizations (NGOs), banks/investors, consumer goods manufacturers, traders, and also palm oil producers to create the Roundtable on Sustainable Palm Oil (RSPO) standard, a standard that aims to minimize the negative impact of the development of the palm oil industry (Ruysschaert & Salles, 2016). In line with these international efforts, the Indonesian government, with strong support from Indonesian Palm Oil Association (IPOA), has also created an instrument that is mandatory for all palm oil business actors in Indonesia, known as the Indonesia Sustainable Palm Oil (ISPO) which was launched in March 2011 (Pareira, 2021), accompanied by regulations on the suspension of land clearing for palm oil plantations.

Although RSPO and ISPO were made to minimize the negative impact of oil palm plantation development, in practice, the effectiveness of RSPO and ISPO certification in protecting social and environmental interests in the palm oil industry has been called into question (Ruysschaert & Salles 2014; De Man & German, 2017; Chalil & Barus, 2020). From an environmental perspective, this certification can facilitate the expansion of palm oil plantations. Certified palm oil production still leads to severe deforestation and may be no more sustainable than non-certified productions (Gatti & Velichevskaya, 2020; Gatti et al., 2019). Despite having received certification, Indonesia's palm oil smallholders remain vulnerable from a social and economic perspective. They often experience uncertainties in market accessibility and are often confronted with price fluctuations, coupled with a lack of capital, in some cases, they also don't get the training that should be given to increase oil palm productivity, causing them to have limited knowledge about the latest agronomy issue/practice, making it difficult for them to obtain the productivity they should get from oil palm plantations (Hidayat et al., 2015; Vermeulen & Goad., 2006; Brandi et al., 2015).

Different story with the regulation on the suspension of land clearing for oil palm plantations, which is commonly known as the oil palm moratorium. This regulation is considered successful in suppressing the rate of deforestation (Gaveau et al., 2016; Vijay et al., 2016). In Indonesia, the proportion of new oil palm plantations replacing forests decreased from 53% in 1995-2000 to 18% in 2010-2015 (Austin et al., 2017). The moratorium regulations no longer allow the establishment of oil palm plantations in forest areas. However, the Indonesian government still allows the development of oil palm plantations in non-forest areas that are not productive. As a consequence, the current development of oil palm plantations is generally built on land commonly used by the community for *ladang* (local agricultural practice). In Indonesia, the proportion of new palm oil plantations replacing non-forest areas increased from 22.1% in 1995-2000 to 37.9% in 2010-2015 (Austin et al., 2017).

2.4 Conclusion

Local farmers' decisions related to land management are influenced by two factors, namely external and internal factors. These two factors influence each other to produce an action for the use of their land. In increasing land use, every decision will be accompanied by consequences that the decision-maker must bear. In the context of this research, the impact that occurs is the loss of forest cover due to the change in the land-use pattern chosen by local farmers.

CHAPTER 3. STUDY METHODS

3.1 Site Selection

Figure 2 Tonggong Village and The Local Communities

The location of the study is in Dusun Tonggong, Parindu, West Kalimantan, Indonesia. Dusun Tonggong is one of the villages in Parindu in which the community is actively involved in the development of palm oil - both plasma plantations (community-owned palm oil plantations which are managed by the company) and small-scale plantations (owned and managed by the community). This study focuses on local case studies as it can provide lessons learned that matters for global change. The local case study is also important for policymakers as it helps identify the mix of patterns of land-use change on a local, national, and international scale (Angel et al 1998; Veitayaki, 2006).

The involvement of the local community in the development of palm oil causes the land-use change pattern in this area is changing. Dusun Tonggong has an area of around 1,400 hectares. Based on the interview in 2019 with the village head of Dusun Tonggong, in 1990 before palm oil came, this area used to be dominantly secondary forest, *ladang*, and rubber agroforestry (a combination between rubber and secondary forest). The local community heavily relies on *ladang* to fulfill their daily needs and they use rubber agroforestry to make additional income.

Figure 3 PTPN XIII State-Owned Enterprise

In 2000, PTPN XIII - a state-owned plantation company- brought palm oil to this area. The local community in Dusun Tonggong decided to be actively involved in the development of palm oil with the plasma system (a system that requires people to sell their palm oil products to the company - in this case, PTPN XIII), without neglecting their old farming systems such as *ladang* and rubber agroforestry. Using the plasma system, each household in Dusun Tonggong developed a minimum of 2 hectares of palm oil plantations, with capital provided by PTPN XIII.

3.2 Mixed Methods (Explanatory Design)

This research uses a mixed-methods approach with an explanatory design research strategy. This strategy always starts with the collection and analysis of quantitative data in the first stage, followed by the collection and analysis of qualitative data in the second stage, which is built based on the initial results of the quantitative analysis in the first stage (see **Figure 4**). More priority is given to quantitative data in the explanatory design research strategy.

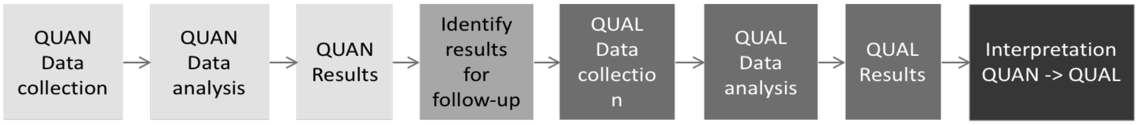


Figure 4 Mixed Methods (Explanatory Design)

Explanatory design is usually used to explain and interpret quantitative results with data collected and analyzed based on a qualitative approach. These designs are beneficial when unexpected results emerge from quantitative research (Morse, 1991).

3.3 Data Collection

In this study, the data are classified into two types: quantitative and qualitative data, according to the need for mixed methods. The first step is to collect quantitative data, which consists of primary and secondary data (see table 2).

Table 2 List of Quantitative Data

List of Quantitative Data	Sources of Data	Tools of Analysis
Financial Report	Financial Report from PTPN XIII	Extended Cost-Benefit Analysis
Environmental Services	Past research (Cahyandito & Ramadhan, 2015); and PTPN XIII Document for the value of LCC (Leguminous Cover Crop) & Leaf midrib	Extended Cost-Benefit Analysis
Landsat Data	Field Survey using a global positioning system (GPS), 75 points in the Dusun Tonggong area	Geospatial Analysis
Farm/Land Size	Field Survey	Agent Based Model
Labor (Family Size)	Field Survey	Agent Based Model
Financial Capital	Field Survey	Agent Based Model

3.4 Community Survey

To get a complete picture of the findings from the quantitative data collection, a community survey was conducted from August 2016 to January 2017 and from March 4 to March 16, 2018 at Dusun Tonggong, Parindu, West Kalimantan. This village has 40 households, because the population in this area is very small population (less than 50), I take almost the entire population in order to achieve accuracy. Each of them has oil palm plantations with a plasma scheme as well as land area to build *ladang* using a shifting cultivation system. Each family usually has a 4 ha oil palm plantation and a 2 ha *ladang*. The survey aims were: to know more about land classification from Dayak people in Seketam Village, to identify the type of commodities that Dayak people obtain from *ladang*, to understand the necessary process to build *ladang* with a shifting cultivation system, to find out about recent obstacles Dayak people face in building *ladang*, and to find out the division of labor in a local farmers family,

We conducted interviews to get information on land classification as well as on the process for and obstacles to building *ladang*. We also distributed questionnaires to gather information about commodities that the Dayak people get from *ladang*.

Key informant interviews were conducted with several people who have knowledge about oil palm issues in PTPN XIII Parindu. The interviews were divided into three categories to get more comprehensive perspective. The first category is the expert perspective, which aims to understand the main issues of oil palm plantations in West Kalimantan. The second category is the corporate perspective, which aims to understand oil palm plantation practices and obstacles, as well as the main issues regarding the development of oil palm plantations. The third category is the community perspective, which aims to identify the practices of oil palm plantation from the community point of view and the main issues of oil palm development based on the community opinion.

CHAPTER 4. GEOGRAPHIC INFORMATION SYSTEM ANALYSIS

The arrival of oil palm commodities affected the land-use pattern in Dusun Tonggong, West Kalimantan. A government regulation that does not allow the establishment of oil palm plantations in forest areas to reduce the impact of oil palm on deforestation rates, in essence, has a negative effect that needs to be considered. One of the impacts of zero-deforestation commitments on a specific commodity is the pressure on forest areas indirectly caused by the need for subsistence plantations from the local community surrounding the area (Mosnier et al., 2017).

Many studies have discussed the effectiveness of zero-deforestation commitments (Gibbs et al., 2015; Heilmayr & Lambin, 2016; Lambin et al., 2018; Junior & Lima, 2018). some of the literature states that zero-deforestation commitments are moderate to significant success. However, some of them mention that prudence is needed in carrying out these committees because the results have considerable uncertainty about their impacts. Focusing only on forest cover without considering its social aspects causes a narrow view of this commitment because a tropical forest is supposed to be a socio-environmental system (Newton & Benzeev, 2018). This chapter tries to provide field evidence of the impact of zero-deforestation commitments on the surrounding forest's condition without releasing its social aspects. The finding of this section is expected to answer the question, "How is the condition of secondary forests due to indirect deforestation?".

4.1 Geographic Information System (GIS) Analysis

Considering the scope of the study is local, geospatial analysis is chosen to help present information about the past land-use change in the study area. As mentioned by Jiang and Yao (2010), geospatial analysis can contribute to presenting useful information and knowledge from massive geographic information. The geospatial analysis that is used is the Geographic Information System (GIS). GIS is an effective tool for detecting and analyzing land cover in a certain area and its changes in several vulnerable periods of time (Chowdhury et al, 2020), which is suitable for the study needs.

4.2 Material and Methods

The field survey to collect data was conducted from March 4 to March 16, 2018. Geospatial analysis was used to identify the location in each area of Dusun Tonggong. Using a global positioning system (GPS), 75 points in the Dusun Tonggong area were successfully identified including areas of palm oil, communal forest, and rubber agroforestry. Visual image interpretation was done using ArcMap 10.7 software and Analysis toolbox. Interpretation results from each year then intersected to see changes over a period of time, based on the intersected areas (Table 3). The land-use change analysis result is classified into three criteria based on local practices:

(1) Direct deforestation into fields - loss of forest cover due to the development of *ladang* practice by the local community in Dusun Tonggong,

(2) Direct deforestation into palm oil - loss of forest cover due to palm oil plantation practices by the local community of Dusun Tonggong, and

(3) Indirect deforestation - loss of forest cover driven by the development of palm oil plantations in *ladang* area that caused the community to open a new area for growing food in the forest areas.

Table 3 Listing the Detailed Band Composites, Image ID, and Corresponding Sensors

Year	ID	Sensor	Composite
1990	LT05_L1TP_121060_19890613_20170203_01-T1	Landsat 5 ETM	5-4-3
	LT04_L1TP_121060_19900523_20170130_01_T1	Landsat 4 TM	5-4-3
2000	LT05_L1TP_121060_20000611_20161215_01_T1	Landsat 5 TM	5-4-3
2010	LE07_L1TP_121060_20110125_20161210_01_T1	Landsat 7 ETM+	5-4-3
	LE07_L1TP_121060_20091018_20161217_01_T1	Landsat 7 ETM+	5-4-3
2018	LC08_L1TP_121060_20171117_20171122_01_T1	Landsat 8 OLI	6-5-4

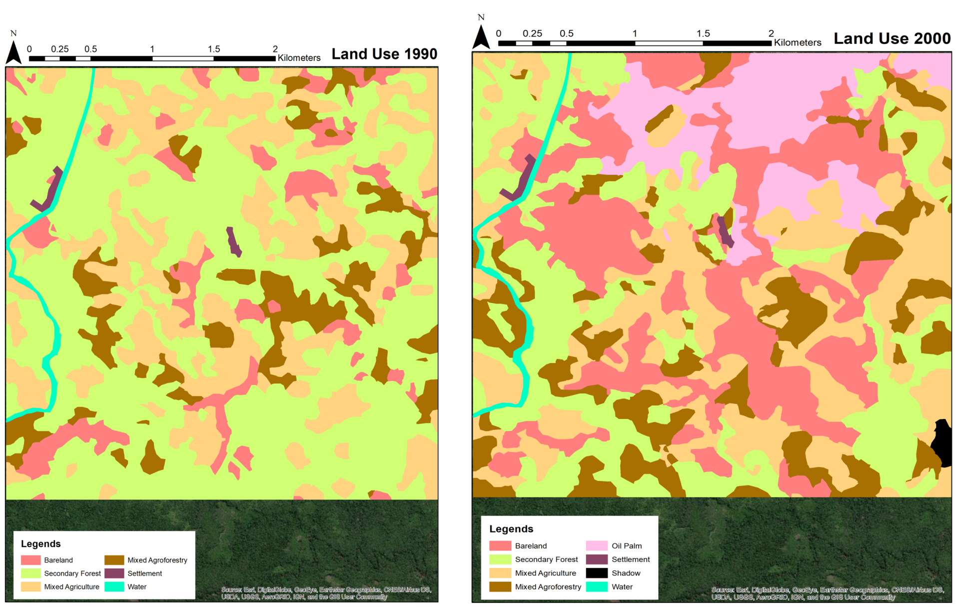
4.3 Calculation

The analysis uses two datasets to analyze land-use changes: prior to 2018 and after 2018. Four images from the 1990-2018 period were used, allowing land-use change analysis in a 10-year period. Images were visually interpreted using Landsat imageries with false composite emphasizing on vegetation and biomass composition (USGS 2020). **Table 3** is listing the detailed band composites, image ID, and corresponding sensors. The visual interpretation data is verified using 75 survey points (sub-chapter Data Collection Instrument) and Google Earth when available. The image was composited and clipped using SNAP Desktop 7.0. Import feature in SNAP Desktop allows for smooth and consistent color composite and clipping dimension.

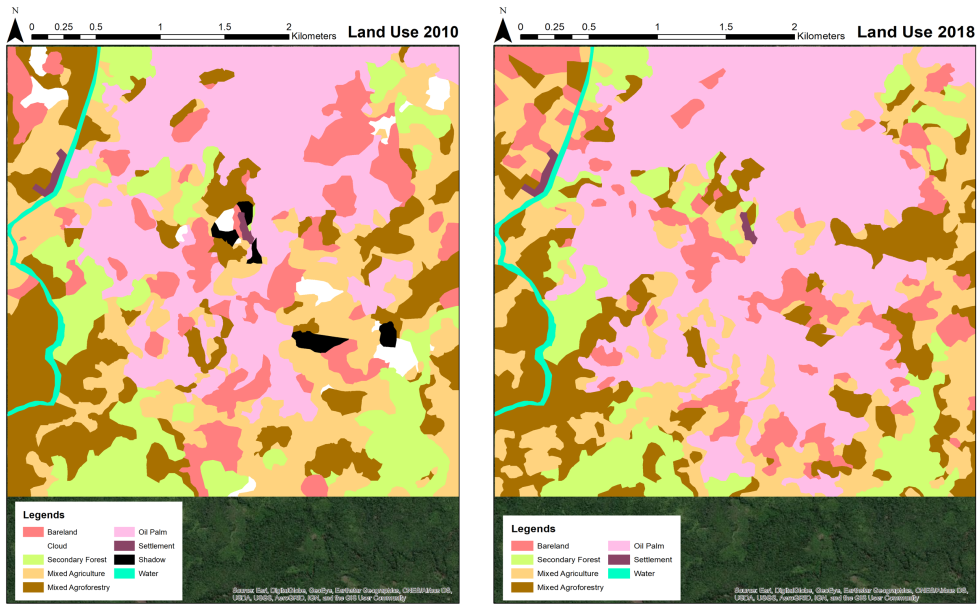
4.4 Geospatial Analysis Result

Before 2000, the people of Dusun Tonggong heavily relied on *ladang* practice to fulfill their subsistence needs. They used secondary forest or bare land and convert it into *ladang* located around their residential area.

The arrival of palm oil in the Dusun Tonggong area changed the way local people manage their land. In the early days of the arrival in 2000, palm oil development was carried out in secondary forests or bare land areas so that it did not disturb the *ladang* area. However, in 2011 the Government of Indonesia suspended palm oil development in peat land and forest areas eventually affecting the land management practices in Dusun Tonggong. As a result, palm oil plantations are no longer developed in secondary forest areas but rather in *ladang* to residential areas before moving to the frontier of secondary forest (**Figure 5**).



(a) (b)



(c) (d)

Figure 5 Land-use Change Dusun Tonggong from 1990 to 2018 (Source: Primary Data from Field Survey, 2018)

The GIS calculations show that the total area of secondary forest converted into *ladang* and palm oil plantations due to direct deforestation is 189.74 hectares and 78.25 hectares respectively. Meanwhile, changes in the secondary forest due to indirect deforestation into palm oil plantations area 149.16 hectares, as shown in **Table 4.**

Table 4 Total Area of Land-use Change from Secondary Forest

Type of Land-use Change	Land-use Change from Secondary Forest 1990-2018 (Ha)
Direct deforestation into *ladang*	189.74
Direct deforestation into palm oil	78.25
Indirect deforestation	149.16

4.5 Discussion

Direct deforestation into *ladang* generally occurs in the early phases before the arrival of oil palm in the Dusun Tonggong area. In this period, people in Dusun Tonggong area depended heavily on the *ladang* area as their primary food source. This condition made the community quite massive in opening up new land for *ladang* practice by cutting down secondary forests. *Ladang* is land area used by the local people in Dusun Tonggong to plant corn, rice, yam, etc. for their subsistence needs. To conduct *ladang* practice these local people use a shifting cultivation system: a simple rotation system of farming in which shrub is slashed and burnt to make *ladang* (Fox et al., 2000). Shifting cultivation practice is a system passed on from generation to generation by these local people. This system is a sustainable system for land condition such as in West Kalimantan (where the mineral soil conditions do not have enough nutrients, like in the Java region). With a rotation time of eight to fifteen years, this system allows the soil to regenerate, which enhance the fertility and the production level of the soil. To open *ladang*, the local people in Dusun Tonggong need to conduct five steps consisting of (1) *nebas* (cutting shrubs), (2) drying, (3) *nyocol* (burning the land), (4) planting, and (5) harvesting. These five steps in the process of *ladang* are shown in figure 6. The cycle in figure 6 keeps repeating until they decide to open the new area for *ladang*.

Figure 6 Process of Ladang

At present, the secondary forest area is open due to indirect deforestation, and it has a significant value of 149.16 hectares. Indirect deforestation is the result of the decision of the people in Dusun Tonggong to move their *ladang* to secondary forest areas, as they consider it less profitable than palm oil plantations. The people of Dusun Tonggong generally plant oil palm plantations in the areas near the settlements that used to function as *ladang* and move their *ladang* area to the forest areas. Based on the results of interviews with key informants this is due to several things:

1. To harvest oil palm requires access to infrastructure
2. People in Dusun Tonggong tend to place their productive assets in areas close to settlements, which are easy to control.

4.6 Conclusion

The high number secondary forest is open through the process of indirect deforestations in the Dusun Tonggong was triggered by the arrival of oil palm plantations in the area. This has initiated the people of Dusun Tonggong to replace their *ladang*, which are close to settlements or reachable by infrastructure, with oil palm plantations and move their fields to forest areas.

CHAPTER 5. EXTENDED COST-BENEFIT ANALYSIS (ECBA)

Some researchers who examined the impact of palm oil plantations quantitatively stated that the land-use change in oil palm plantations positively impacted the community's development (Euler et al., 2017; Prabowo et al., 2017). Meanwhile, several other researchers who conducted studies on the social dynamics of communities around palm oil plantations stated that the land-use change in palm oil plantations has more negative impacts on the community (Sirait, 2009; Sokhannaro, 2011). The debate on palm oil is considered normal since there are different perspectives in analyzing the effects of palm oil. Palm oil will have positive impacts when we see this commodity as a source of community welfare that opens job opportunities for the local community. On the other hand, palm oil will have negative impacts when we see that oil palm has the potential to cause land alienation, loss of livelihoods, social conflicts, exploitative labor relations, and degraded ecosystems (Colchester et al., 2007).

Despite the aforementioned facts, there is a lack of studies that summarize the results of quantitative impact calculations with the results of studies that describe the social dynamics of society around oil palm plantations. These two aspects are important to be evaluated in one research because both are necessary to achieve sustainability. The finding of this section is expected to answer these question, "What are the factors that caused the local farmers to conduct indirect deforestation?".

5.1 Extended Cost-Benefit Analysis (ECBA)

This research intends to calculate not only economic and environmental factors through the ECBA method. A cost-benefit analysis (CBA) method may be prone to weakness in valuation due to the difficulty of reflecting the heterogeneity of different parameters (Schaafsma & Brouwer, 2006). To address this weakness, supplementary analyses of social, health, and environmental benefits are often introduced (Chutubtim, 2001). These additional supportive approaches are often acknowledged as an extended CBA framework (Fahrudin, 2003). ECBA is a particular manifestation of CBA with an especially careful look at social and environmental impacts — the hidden external costs normally unaccounted for in decision making (Global Green Growth Institute, 2014).

5.2 Material and Methods

5.2.1 Environmental Services Valuation

Table 5 Value of Environmental Services in Dusun Tonggong Area (In Rp.)

Ecosystem Services	Scheme					
	A	B	C	D	E	F
Provisioning Food	854,063	854,063	854,063	854,063	854,063	854,063
Recreation	21	41	21	41	21	41
Pest Control	1,344	1,344	1,344	1,344	1,344	1,344
Water and Soil Conservation	960,468	960,468	135,693	135,693	1,096,162	1,096,162
Total Value	1,815,896	1,815,916	991,121	991,141	1,951,590	1,951,610
	LCC (Leguminous Cover Crop)		Leaf Midrib		LCC & Leaf Midrib	

The ecosystem functions identified for the research area include five services: (1) provisioning services, (2) cultural services, (3) regulation services, (4) soil preservation, and (5) water preservation. To calculate provisioning services, a market price approach is used. The calculation is based on all the food collected by local communities from the *ladang*, all those commodities are then converted using local market prices. For cultural services (recreation), the approach used is the willingness to pay from people outside the Dusun Tonggong area and assume that the Dusun Tonggong area is used as a recreation and conservation area. For regulation services (pest control), the calculation used is the cost incurred by the community to prevent pests in their ladang area. The provisioning services, cultural services, and regulation services are already calculated by Cahyandito and Ramadhan (2015) in previous research and will be used in this research to calculate extended cost-benefit analysis.

Table 6 Total Water and Soil Conservation Value in Different Scenario

Scenario	Total Rp/Ha/Year
Cover Crop	960,468
Leaf Midrib	135,693
Cover Crop & Leaf Midrib	1,096,162

The soil preservation and the water preservation services are considered based on Indonesian policy and High Conservation Value (HCV) Toolkit's "environmental services" (HCV 4) which are both mentioned in the working paper by Gingold and colleagues (2012). To calculate water and soil conservation as environmental services from shrubland, we used a replacement cost method with the assumption that these environmental services can be replaced by using three kinds of alternatives: (1) using LCC (Leguminous Cover Crop), (2) using leaf midrib (part of the oil palm that must be pruned to keep the quality of oil palm fruit), (3) using a combination between cover crop and leaf midrib. We used secondary data from PTPN XIII to calculate the value of LCC and leaf midrib.

The selection of these five types of ecosystem services is based on the conditions in the research area and the environmental benefits felt by the community in Dusun Tonggong. In the calculation these five ecosystem services are assumed to be lost if the one thousand hectares of land owned by the village changes into oil palm plantations. Therefore, these five ecosystem services will be included in the calculation of environmental cost using the ECBA method.

Apart from the debate about the Fisher effect, the interest rate was also included in the calculation to show local inflation in the Sanggau area. As mentioned by Fisher, a permanent change in the rate of expected inflation will cause an equal change in the nominal interest rate in the long run (Fisher, 1930). This research uses interest rate data of the Sanggau area for the past ten years in which we noted the lowest, moderate, and highest inflation in the period. We used three scenarios based on the variation of the local inflation rate: (1) when the local inflation is 10%, (2) when the local inflation is 8%, and (3) when the local inflation rate is 4%.

5.3 Economic Comparison Result

For Dayak people, the economic benefit is an important aspect to consider when they are deciding to change their land from one commodity to another. Considering this, it is necessary to compare the economic benefits of *ladang* with a shifting cultivation system to those of oil palm plantation, considering not only the income obtained but the environmental value from ecosystem services as well. There are three scenarios based on the variation of the local inflation rate: (1) when the local inflation is 10%, (2) when the local inflation is 8%, and (3) when the local inflation rate is 4%.

To undertake the evaluation using ECBA for oil palm plantations, first, we classified oil palm into four phases. The first phase is a small fruit phase, a phase in the 0 to 3rd year of oil palm when the trees do not have fruit that produces oil. In general, at this phase, the company or the farmer does not have any earnings from oil palm yet. Hence, the cost in this phase is calculated as the investment cost. The second phase is the early production phase, a phase in the 4th to 9th year of oil palm, in which the fruit already produces oil, Though the fruits already produce oil, in the 4th and 5th years, there are still investment costs. The third phase is the mature production phase, spanning from the 10th to 20th years. In this phase, oil palm produces oil at the optimum level. The fourth phase is when oil palm produces less oil because of aging, a phase in the 21st to 25th years.

In this research, there are 7 schemes to calculate ECBA. The schemes were developed with consideration of varied results from the tools we used to analyze the environmental services. The calculation of ECBA in this study uses seven scenarios, which are as follows:

(1) the calculation of CBA excluding the environmental cost,
(2) the calculation of CBA including the environmental cost (provisioning food, recreation-lowest value, pest control, and LCC)
(3) the calculation of CBA including the environmental cost (provisioning food, recreation-highest value, pest control, and LCC)
(4) the calculation of CBA including the environmental cost (provisioning food, recreation-lowest value, pest control, and leaf midrib)
(5) the calculation of CBA including the environmental cost (provisioning food, recreation-highest value, pest control, and leaf midrib)
(6) the calculation of CBA including the environmental cost (provisioning food, recreation-lowest value, pest control, leaf midrib, and LCC)
(7) the calculation of CBA including the environmental cost (provisioning food, recreation-highest value, pest control, leaf midrib, and LCC)

The scenarios were developed based on the type of alternative that will be used to conserve land and water as well as based on the highest and the lowest value of cultural services. A detailed calculation for those seven scenarios is shown in Appendix table A1 until A7. There is a range of high and low-value cultural services and three alternatives to conserve water and soil that have a role in shaping the scheme.

Table 7 Economic Comparisons

	Inflation Rate		
	10%	8%	4%
NPV of palm oil	$ 736.4 - $1,179.8	$ 1,050.1 - $ 1,565.2	$ 2,023.6 - $ 2,755
NPV of *ladang*	$ 16.3 - $ 491	$ 19.1 - $ 804.7	$ 25.5 - $ 804.7

This study uses the lowest average inflation rate (when the local inflation rate is 4%), moderate (when the local inflation rate is 8%), and the highest (when the local inflation rate is 10%) based on actual data obtained. in the field within five years 2013-2018. The NPV calculation is done using Microsoft Excel by calculating the net profit value from oil palm plantations per year within a 25-year timeframe adjusted for three predetermined inflation values. Table 5 summarizes the calculation results taking into account the value of inflation and seven scenarios from ECBA by taking the lowest and highest values. Based on the calculations in all of the scenarios, taking the potential loss of environmental services into account, it is financially feasible to create oil palms in shrublands with mineral soil. Economically, the value of oil palm is higher than the value of *ladang* with a shifting cultivation system, as shown in **Table 7**. This is why the role of *ladang* began to shift, and they placed oil palms as more profitable sources for them close to their homes and moved their *ladang* to the frontier forest.

5.4 Discussion

The financial benefits of the people of Dusun Tonggong from oil palm have changed the community's paradigm, from previously subsistence needs-based to commercially-based. The community sees that oil palm gives hope to improve their welfare without having to leave the cultural roots that they have guarded so far. However, they can only maintain this as long as they still have a fairly large area of customary land as it is today.

5.5 Conclusion

The changing paradigm of Dayak people leading them to convert their *ladang* with shifting cultivation to oil palm plantation cannot be avoided. They prefer to conduct oil palm plantation because of three main factors: (1) economic, (2) labour force, and (3) land area. In terms of the economic factor, this study proves through ECBA calculation that oil palm plantation gives more benefit than *ladang* with shifting cultivation, even after considering the loss of environmental services as a cost from changing to oil palm plantation.

CHAPTER 6. AGENT-BASED MODELS

The existence of negative impacts caused by zero-deforestation commitments must be a severe concern to prevent the unintended consequences of deforestation prevention policies. In the long term, it helps to achieve sustainable forestry, where local communities can live in harmony with nature while maintaining their well-being. At present, studies on the phenomenon of indirect deforestation are still limited. Existing studies only discuss the indirect deforestation phenomenon as a general concept (Gatto et al., 2015; Mosnier et al., 2017; Macedo et al., 2012; Arima et al., 2011).

This chapter discusses indirect deforestation in Dusun Tonggong, West Kalimantan, Indonesia. Dusun Tonggong is a region that rearranges its land-use pattern to adapt to palm oil expansion. The findings from this research are expected to answer the following question: "How can the indirect deforestation phenomenon affect the local farmers' future?".

6.1 Agent-Based Models

Agent-Based Models (ABM) are used in this study to predict the possibility of land-use change in three scenarios designed based on the agent typology. ABM is basically developed for local case studies generally used to simulate land-use change generated by various variations in individual decisions and actions (Matthews et al. 2007; Parker et al. 2003, 2008; Robinson et al. 2007). All forms of decision-making strategies can be described and quantified using this method through individual questionnaires or participatory calibration (Bousquet and Le Page, 2004; Janssen and Ostrom, 2006; Robinson et al., 2007). In addition, ABM is an effective approach to simulating the interactions between humans and ecosystems (Bai et al, 2015) and it also allows us to explain people's behavior in a system (Namany et al, 2020).

6.2 Material and Methods

6.2.1 Agent Typology

To simplify the differences in the decisions of the people in Dusun Tonggong area in using their land, an agent typology is proposed. Agent typology is based on the willingness and ability of a community in the context of land expansion and diversification of land use owned by the community (Valbuena et al, 2010). In this study, the agent typology used by

Valbuena et al, 2010 is modified by adjusting to the existing conditions of the local communities in Dusun Tonggong. The agent typology adjusted in this research is divided into three, which are as follows:

(1) **Conventional**, which shows the people seeking to practice *ladang* (local plantation practices with a shifting cultivation system, usually planted with crops for subsistence needs) and refraining from developing palm oil in their area. The assumption for the Conventional is that people directly cut their secondary forest to convert it into *ladang* (direct deforestation by *ladang*);

(2) **Diversifier**, which represents a community that wants to develop palm oil and leave *ladang* practices. The assumption that we built for the Diversifier is that the community directly cuts down their secondary forest for palm oil (direct deforestation by palm oil);

(3) **Expansionist-Diversifier,** which represents a community seeking to develop both palm oil and ladang in their area. The assumption for the Expansionist-Diversifier is that the community uses the land for palm oil plantations before shifting the ladang to secondary forest areas.

6.2.2 Simulation Model Assumptions

To simulate the ABM in the Dusun Tonggong area, we designed an assumption model based on the actual condition in the Dusun Tonggong area portrayed by the primary and secondary data collected. In this case, we use primary data from the interview and questionnaire survey in Dusun Tonggong as well as secondary data from PTPN XIII report, Statistical Agency (BPS) report, and Department of Forest and Estate Crops of West Kalimantan report.

Through the questionnaire, we obtained information on the labor force, land area, and economic factor to analyze the abilities of Dusun Tonggong community. For the labor force factor, we collected data related to population growth, the average age at marriage, the average age when buying a house, and the average productive age for carrying out agricultural activities. We input the data that we get to the Netlogo software, as a basis for predicting the availability of labor in Dusun Tonggong in the future. For the land area factor, the data we collected through the questionnaire is data related to the farm size, where the people of Dusun Tonggong generally own 2 Ha of palm oil and 1 Ha of *ladang*. We used data regarding farm size in the simulation to predict local community patterns in clearing land in the future. For the economic factor, we collected data related to the capital, income, and cost spent by a household to carry out agricultural activities. We input economic data into the model to predict the total financial accumulation of the community which is also related to the ability of the local community to develop their land in the future.

Key informants were also interviewed to understand the land use pattern and the willingness of the Dusun Tonggong communities, which might be affected by the local cultural values. Through this interview, it is found out that in Dusun Tonggong, palm oil production will decline after 22 years old, and they will cut down the palm oil. This information is used as an assumption for the model.

All available data were inputed to the ABM, and then simulated using the Netlogo 6.1.1 software (http://ccl.northwestern.edu/netlogo/), with the simulation process shown in **Figure 7.** There were three simulation scenarios based on agent typology with a span of 40 years. What distinguishes the 3 simulations is the assumption of willingness from the local community, which are as follows:

(1) Conventional simulation (direct deforestation by *ladang*): the local community is assumed to be willing to develop only *ladang*, not palm oil plantations
(2) Diversifier simulation (direct deforestation by palm oil): the local community is assumed to be willing to clear the land only for palm oil plantation
(3) Expansionist-diversifier simulation (indirect deforestation): the local community is assumed to be willing to develop palm oil plantations and ladang simultaneously.

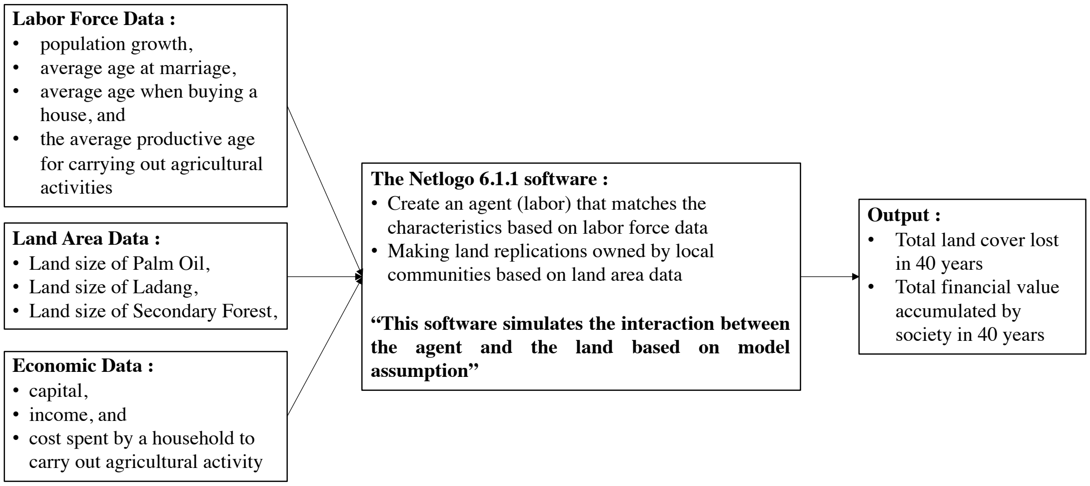


Figure 7 ABM Simulation Process

6.3 Agent-Based Model Result

To determine the amount of secondary forest cover lost in the Dusun Tonggong area in the next 40 years, a simulation of three scenarios based on agent typology has been conducted.

6.3.1 Simulation for Conventional Scenario (Direct deforestation by *ladang)*

The Conventional Scenario simulation result is shown in **Figure 8.** In this scenario, it is predicted that the area of secondary forest in Dusun Tonggong will only decrease by 213 hectares in the next 40 years or 18% from the total secondary forest area in 2018. Thus, the area of secondary forest cover disappearing annually is only 0.5%. From the financial aspect, the estimated total financial profit earned by the people of Dusun Tonggong for the next 40 years if they only practice *ladang* is Rp 80,700,000,000 ($5,279,902.57; 1 Rupiah equals to 0.000071 USD).

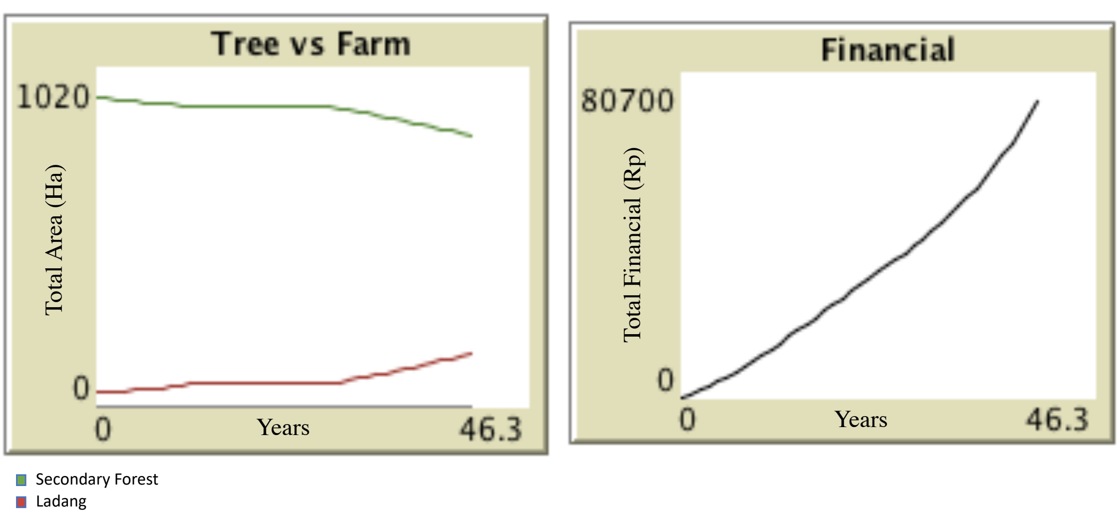


Figure 8 Simulation for Conventional Scenario (Direct deforestation by ladang)

6.3.2 Simulation for Diversifier Scenario (Direct deforestation by palm oil)

The Diversifier Scenario simulation result is shown in **Figure 9.** This scenario assumes that the entire community of Dusun Tonggong is a diversifying community. The results of the total loss of secondary forest cover in the Dusun Tonggong area for the next 40 years from this simulation are 407 hectares (43% of the total area of secondary forest in 2018). This means that the area of the secondary forest cover lost per year is 1.1%. From the financial aspect, the estimated total profit gained by the people of Dusun Tonggong from this practice in the next 40 years is Rp 105,000,000,000 ($7,437,685.50; 1 Rupiah equals 0.000071 USD).

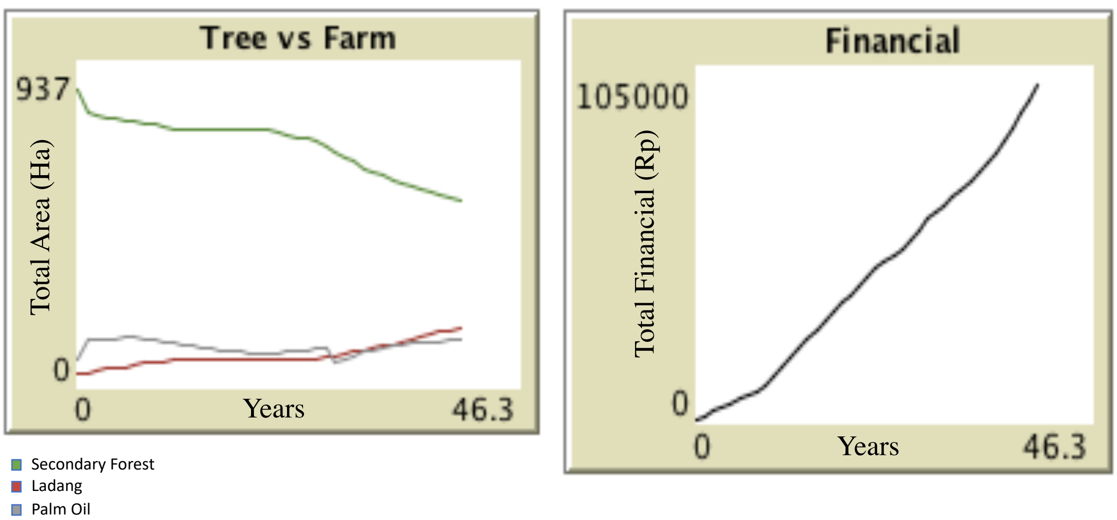


Figure 9 Simulation for Diversifier Scenario (Direct deforestation by palm oil)

6.3.3 Simulation for Expansionist-Diversifier Scenario (Indirect deforestation)

The Expansionist-Diversifier Scenario simulation result is shown in **Figure 10.** The simulation shows that there has been a reduction in secondary forest cover by 306 hectares for 40 years or 31% of the total area of secondary forest in 2018. Thus, it is estimated that the total area of secondary forest cover will decrease by 0.8 % per year. Meanwhile, from the financial aspect, with this scenario, the community of Dusun Tonggong will get a total financial profi tof Rp 87,300,000,000 for 40 years ($ 6,183,904.23; 1 rupiah equals 0.000071 USD).

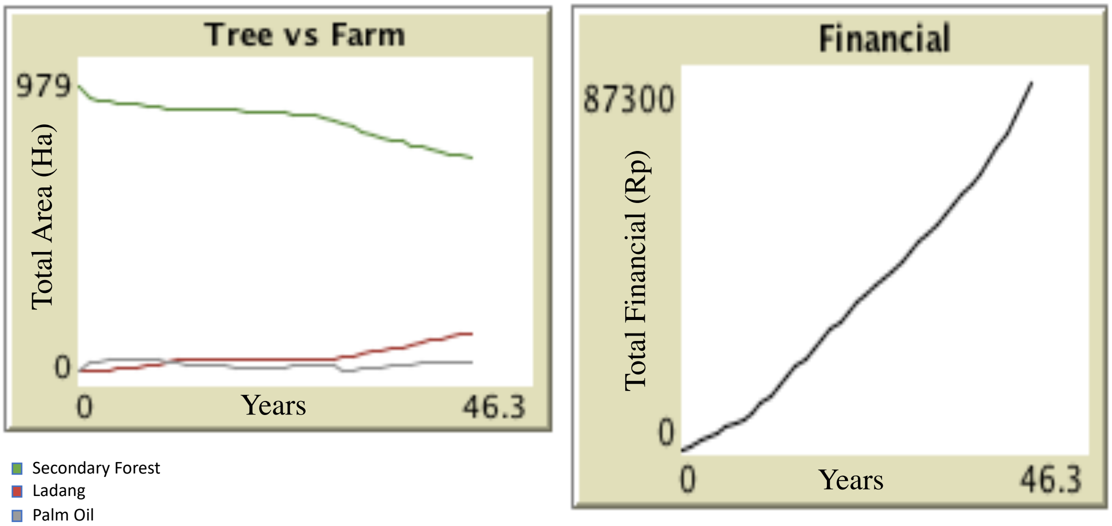


Figure 10 Simulation for Expansionist-Diversifier (Indirect deforestation)

6.3.4 Simulation Result in Actual Condition

The ABM simulation presents the possibility of land-use changes in the next 40 years in Dusun Tonggong based on the three scenarios adjusted to the possibility of decision-making by the local community. The summary of the result of the simulation is shown in **Table 8.**

Table 8 Simulation Results for Forest Loss and Financial Revenue through Three Simulation Scenarios

			The current actual condition in Dusun Tonggong
Parameters	**Conventional (Direct deforestation by ladang)**	**Diversifier (Direct deforestation by palm oil)**	**Expansionist-Diversifier (Indirect deforestation)**
Forest Loss (40 years)	18%	43%	31%
Total Financial Revenue (40 years)	80 billion	105 billion	87.3 billion

Based on the simulation, the largest percentage of land cover loss (43%) occurs if the entire Dusun Tonggong community chooses to become a Diversifying community (direct deforestation by palm oil). On contrary, if the Dusun Tonggong people are entirely conventional (causing direct deforestation by ladang), the amount of secondary forest land cover lost in 40 years is only 18% of the total current secondary forest cover. Ecologically, the shifting cultivation practice carried out by the people of Dusun Tonggong is much better when compared to the diversifier decision. However, the amount of income that the Dusun Tonggong people obtain is much lower than the Diversifying choice.

6.4 Discussion

The decision of the people of Dusun Tonggong to become a Diversifying community has both positive and negative consequences. As a positive consequence, the community becomes a little more resistant to changes in the conditions of the oil palm plantation industry. This is because they still have ladang that they can still rely on. The negative consequence is that using land for ladang and converting it to oil palm plantations makes the people of Dusun Tonggong have to move their ladang to forest areas, which is the cause of indirect deforestation. If this continues, the people of Dusun Tonggong will lose all of their secondary forests within the next 40 years.

6.5 Conclusion

The total loss of the secondary forest due to uncontrolled indirect deforestation will lead to a lack of land to grow plants that support people's daily needs. If such condition happens in the future, it will distance Dusun Tonggong people to lose their basic survival needs. Therefore an alternative solution is needed to reduce indirect deforestation in this region by changing the management system from an individual system to a communal system and an alternative by developing a palm oil agroforestry system.

CHAPTER 7. DISCUSSION

7.1 The Changing Paradigm of Dusun Tonggong Communities and Implication

Expansion of oil palm plantations with a zero-deforestation commitment to the Dusun Tonggong area resulted in indirect deforestation with a significant value of 149.16 Ha. This is a consequence of the decision of the people of Dusun Tonggong, who chose to become an expansionist-diversifier community.

Changes in the economic structure from subsistence need to commercial needs (economy), the number of young people living in Dusun Tonggong is decreasing (social), and land conditions (environmental) are internal factors that shape the abilities of the Dusun Tonggong community. A strong desire to maintain the fields as a hereditary legacy from their ancestors shapes the community's willingness. Two internal factors have shaped the people of Dusun Tonggong to become an expansionist-diversifier community. The community well received the arrival of oil palm plantations in the Dusun Tonggongo area without the need to leave the culture passed down from generation to generation.

Figure 11 Palm Oil Plantation Owned by The Local People

In general, the people in the Dusun Tonggong area have an interest in palm oil, as it has significantly boosted the economic condition of the community. Dharmawan et al (2020) explain that the arrival of palm oil, in general, has encouraged economic growth in the region.

People in Dusun Tonggong also like palm oil because it does not need intensive care. In one year, palm oil plantations only need at least three treatments. The low maintenance of palm oil means it requires less labor; providing space for other family members to create new palm oil plantations.

Figure 12 Ladang Practice by Local Community

The Presidential Instruction No. 8/2018 on the Moratorium Policy on Palm Oil Plantations stated that oil palm plantings should be carried out on non-forest land. Considering this statement in the regulation, the act of people of Dusun Tonggong that plant palm oil in *ladang* area is legal. However, the relocation of *ladang* to the secondary forest areas as a result of the opening of palm oil plantations in non-forest areas (*ladang*) has created new problems. Several studies have shown that the same phenomenon also occurs in other regions, especially in Sumatra, Kalimantan, and the Brazilian Amazon (Gatto et al., 2015; Arima et al., 2011). The shift of fields to the secondary forest causes indirect changes in land use called by Gollnow et al. (2018) “indirect deforestation".

7.2 Domination of Palm Oil Plantation

The arrival of oil palm to the Dusun Tonggong area has undeniably changed the community's welfare. Currently, oil palm plantations have become one of the primary sources of income for the people in the Dusun Tonggong area. This is also inseparable from the role of PTPN XIII, which can provide guarantees to the community to buy products from community-owned oil palm plantations. For people in Dusun Tonggong, the economic benefit is an important aspect to consider when deciding to change their land from one commodity to another.

PTPN XIII itself involves the community in developing oil palm plantations with the Nucleus-Plasma estate scheme. This scheme was created with the aim of smallholder development. In this scheme, the nucleus estate guides plasma estate in the context of management, technology (including high-yielding trees), entailing the opening and planting of land, the supply of inputs, and processing (Zahari et al., 2016). Plasma estate is an oil palm plantation managed by the community under the guidance of the nucleus estate.

As shown in the ECBA calculations, oil palm provides financial benefits for the people of Dusun Tonggong. This is one of the factors that motivates the community to participate in the development of oil palm plantations. Several communities have recently started developing their oil palm plantations outside of the Nucleus-Plasma scheme. They replaced land that was originally used for *ladang* with oil palm plantations and opened the new *ladang* in the frontier forest area. The local people's interest changed from subsistence needs-based (*ladang*) to commercial-based (palm oil plantation). There are three major drivers of the change:

1. **Economic**

   Based on the calculation of ECBA, palm oil plantation or *ladang* with shifting cultivation are both financially feasible to build. However, if we look further at the NPV from both practices and consider of environmental impacts, transforming shrubland into an oil palm plantation is still more profitable compared to transforming shrubland into *ladang*.

2. **Labour Force**

   Based on the interview results, to open shrubland of 2 ha until harvesting requires at least 4 to 6 people. Meanwhile, *ladang* is also time-consuming for the Dayak people. This condition becomes an obstacle for some Dayak people in Seketam Village, which causes them to decide to convert their shrubland into oil palm plantations, where they do not need much labor or time.

3. **Land Area**

   Based on the interview results, the area of shrubland for shifting cultivation has become smaller, caused by the increase in population and the land-use changes for commercial plantations. Limited availability of land has forced many farmers to shorten their rotation on shifting cultivation, resulting in a degradation of soil conditions and the productivity of the soil. This has prompted the community to convert its land into oil palm.

7.3 The Dangers of Being Dependence on One Commodity

The people in the Dusun Tonggong area have a strong local culture. They believe that the practice of *ladang* is a legacy from their ancestors passed on to them. However, the community is also open to the arrival of palm oil into their area - which then they add to their existing land use system. They plant palm oil on land that was used as *ladang*, and move the *ladang* to the secondary forest areas.

Practicing *ladang* is an adaptation strategy for survival as well as a way to preserve the legacy of ancestors as suggested by Dharmawan et al (2016) and Martin et al (2016) that income resources diversification provides a better basis for survival. They are well aware of the importance of income diversification based on their experience relying on rubber forests as their source of livelihood. Since the sustainability of a commodity like rubber is often influenced by the global political economy, sustainable market demand is uncertain. This can lead to "devastation" if they rely solely on the uncertainty of world markets. In other words, they do not want to repeat their past mistakes - where they depended their lives on the rubber forest and ended up bankrupt because the market dictated to them.

The way to prevent such a scheme is manifested in the form of palm oil plantations in which they use "cultural" veil. On one hand, they want to improve their welfare by adopting palm oil practice, but on the other hand, they also have to be aware of the "danger" of uncertainty that will affect the sustainability of their communities. Income diversification has been analyzed as a rational response by the household to lack of opportunity for specialization and was not considered as the most desirable option (Amanze et al. 2017).

The Dusun Tonggong people are aware that if they only rely on *ladang*, even though they do not change the forest cover significantly, their lives will not develop much. On the other hand, if they rely solely on palm oil, its sustainability is questionable. Therefore, they preserve "culture" by keep practicing *ladang* as a strategy of adaptation to a new life. This is also in line with the study of Frank Ellis (2000) arguing that to neutralize the negative impacts of relying on a single income stream, households should develop a strategy to diversify their livelihoods (Ellis, 2000).

7.4 Diversification of Income

Figure 13 Diversification Income by Local Community (Ladang, Palm Oil Plantation, and Rubber Agroforestry)

People of Dusun Tonggong decide to continue doing shifting cultivation (*ladang*) and also participate in palm oil development. This choice is a rational choice. Sirait (2009) states that some local people partially engage with palm oil plantations but attempt to maintain their cultural and economic integrity. The people of Dusun Tonggong still use *ladang* as the main source of their food needs, although the local people mention that maintaining both *ladang* and palm oil plantations at the same time is quite time-consuming. However, it is possible to do this by dividing the work among family members. In general, the head of the household will take responsibility to take care of the palm oil plantation owned by the family while other family members focus on maintaining the *ladang*. Toumbourou and Dressler (2020) explain that in the island of Kalimantan, culturally, women usually play a greater role in *ladang* practices, especially to ensure that agricultural production is well preserved. Along with the arrival of palm oil that changed their land status from customary tenure to formal titling, men became more responsible in plantations because the land certificate is held in the name of the household heads (except when households are female-headed).

For the people of Dusun Tonggong, choosing to become an expansionist-diversifying community is a suitable choice as they will not rely on only one commodity as a source of income. As explained by Dharmawan et al (2020), the arrival of palm oil is not the only factor that contributes to rural economic growth. Dharmawan et al (2020) also explained that people keep palm oil solely as an additional source of income to diversify the sources of their livelihoods as the people in the area are profiting from other sources of income. The same reason was also said by the people in the Dusun Tonggong area, where they have benefited from *ladang* as their main source of food as well as from palm oil as an additional income that they use for other needs such as financing education for the younger generation in their area.

However, diversification of income has a negative impact. This may happen if the local people start a palm oil plantation on a land that was initially a local plantation (*ladang*) - causing the local plantation to be moved to the outer side of the forest. Several studies have shown that the same phenomenon also occurs in other regions, especially in Sumatra and Kalimantan, and the Brazilian Amazon (Gatto et al. 2015; Arima et al. 2011). The shift of *ladang* to the secondary forest causes indirect changes in land use called by Gollnow et al (2018) "indirect deforestation".

7.5 Indirect Deforestation

Indirect deforestation is a consequence of the local community's choices to become an expansionist-diversifying society. Indirect deforestation in Dusun Tonggong area can become a threat in the future if it is not appropriately addressed, as shown in the research results, with the current condition, the secondary forest owned by the Dusun Tonggong community will disappear within the next 40 years. Efforts to reduce deforestation without considering the interaction of land-use change between new commodities and old commodities provide deforestation opportunities in other areas. Gollnow et al. (2018) mention this as a deforestation leakage. This leakage remains poorly understood, and few studies have attempted to quantify this phenomenon (Fuller et al., 2019). Like rubber in the past, palm oil is currently an asset that can improve people's welfare. However, in Dusun Tonggong area, *ladang* also needs to be considered a source of food security for local communities and a cultural product that needs to be preserved.

7.6 Alternative to Reduce Indirect Deforestation

The efforts of the people of Dusun Tonggong with PTPN XIII to develop an intensification system by making communal palm oil plantations need to be considered as an effort to avoid indirect deforestation or deforestation leakage. In this communal palm oil plantation, palm oil ownership will no longer be held by each household head. Instead, it will be in the village's hands, where the proceeds will be distributed proportionally to the local community. In principle, making communal palm oil plantations is similar to the cooperative institution practice commonly conducted by the community. However, in the cooperative institution that handles palm oil, what is managed communally is only the harvesting results from palm oil plantations, not necessarily including joint ownership of palm oil plantations. Communal land management practice is also not new to the people of Dusun Tonggong, based on the communal agreement they classify the land into three types (exclude palm oil):

1. Shrubland

   Shrubland is the land area that used by the community to conduct *ladang* using shifting cultivation method. Before oil palm, most of the local people in Dusun Tonggong earned their subsistence needs from *ladang*

2. Rubber Agroforestry

   Rubber agroforestry was the main source of income for local people in Dusun Tonggong before oil palm. However, lately, the price of rubber declining. Despite that fact, nowadays, they keep the rubber agroforestry as an alternative income to oil palm.

3. *Tembawang*

   Tembawang is protected land of the local people in Dusun Tonggong, which they inherited from the previous generation. *Tembawang* is also known as descendant land area, which is mostly used for mixed agroforestry and in some case included sacred forests and graveyards. The benefit obtained from these lands were shared among the descendant group and the community, with approval from the members of the community.

The land classification above shows how the people of Dusun Tonggong have carried out communal management in the agriculture system they have had for generations. Based on this, there is a possibility that communal palm oil plantations can be carried out using the same communal management in the other land functions.

Communal management of palm oil plantations is essential in improving the community's welfare, especially for those who live in limitations such as in rural areas (Chukwukere and

Baharuddin, 2012; Kumar et al., 2015). Powell (1998) stated that communal ownership is more environmentally friendly than private ownership because every individual involved must obey the collectively made rules. Meanwhile, in individual ownership, there is a tendency for each individual to prioritize their respective interests in land management, which often ignores conservation principles and is only concerned with economic benefits alone. However, this does not mean that the communal ownership scheme will avoid each individual's interests. Even in the communal scheme, there is a possibility of individuals trying to take advantage of group risks by "exploiting" and taking advantage of opportunities for their interests, as shown by Hardin (1968) with "tragedy of the commons" - resulting in unsustainable use of joint ownership. This communal management's failure must be overcome by making new rules together (Ostrom, 1990). A commitment to sustainable resource use must also be there. Furthermore, an agreement regarding the rules for using resources is needed (Marten, 2001) to prevent the "tragedy of the commons" as mentioned by Hardin (Cardenas, 2004) from ever happening.

With a joint ownership system for palm oil plantations, the community's economic conditions can be improved, and the growth of palm oil plantations in the area can be reduced. As a result, it will potentially reduce community efforts to open new *ladang* in secondary forest areas.

In managing palm oil plantations, replanting is an essential process to maintain palm oil plantations' productivity - it is also practice similar to land clearing. For replanting palm oil, the Dusun Tonggong community can use a practice that has been done in several neighbouring villages where they develop new palm oil on the same land where they used to plant the old one. A palm oil agroforestry system can also be developed to reduce indirect deforestation. From various studies, it is found that agroforestry systems are in line with efforts to realize sustainable forestry, where the system can provide economic benefits and ecological and social services while also reduce global problems due to climate change. Agroforestry systems can also strengthen food security and sovereignty, especially for rural communities (Abdoellah, 2021).

CHAPTER 8. CONCLUSION

This study discusses the issue of deforestation and smallholder palm oil plantations. The development of the palm oil industry in Indonesia is not only enjoyed by large private/national companies but also by local communities around plantation areas. This study aims to understand the smallholder livelihood strategy in dealing with the expansion of oil palm plantations and the implications of the strategy chosen by the community on the condition of the forest area. This research tries to answer these two main questions:

1. How the local farmers re-arrange its land-use pattern to adapt to palm oil expansion?
2. What are the implications?

In general, this study uses a mixed-methods approach with an explanatory design research strategy. This strategy always starts with the collection and analysis of quantitative data in the first stage, followed by the collection and analysis of qualitative data in the second stage, which is built based on the initial results of the quantitative analysis in the first stage.

Specifically, this study uses three types of methodology: geospatial analysis to see indirect deforestation, extended cost-benefit analysis to calculate the economic and environmental cost and benefit, and Agent-Based Models (ABM) to predict the possibility of land-use change in three scenarios designed based on the agent typology.

"How can indirect deforestation happen in the context of palm oil expansion?" Oil palm provides an opportunity for local communities to develop, especially in terms of socioeconomic conditions. The arrival of oil palm plantations in the Dusun Tonggong area affects the behaviour patterns and actions of the community in managing their land. Today's society tends to change some of the existing lands use into oil palm plantations. This change was driven by three factors: the economic benefits of palm oil plantations, the availability of land owned by the Dusun Tonggong community, and the number of workers.

The paradigm shift of the people of Dusun Tonggong from a subsistence base to a commercial based does not necessarily make the community depend entirely on oil palm plantations. The Dusun Tonggong community chooses to incorporate oil palm plantations into their existing agriculture system as an additional commodity that is economically profitable. On the other hand, they use culture to justify maintaining farming practices. They are aware that dependence on single-income sources (exp: oil palm) can lead to "devastation" for local communities. Therefore, maintaining income diversification is very important. But as a consequence, the people of Dusun Tonggong have to move their *ladang* to secondary forest areas

"How can the indirect deforestation phenomenon affect the local farmers' future?" Income diversification has the risk of triggering indirect deforestation. The need for additional land to maintain their *ladang*, and their desire to establish their oil palm plantations puts pressure on secondary forest areas. This then causes indirect deforestation. The indirect deforestation phenomenon can be a threat in the future if not managed well. In case of the Dusun Tonggong area if indirect deforestation continues, the people of Dusun Tonggong will lose all of their secondary forests within the next 40 years, it means they will lose their basic survival needs in the next 40 years. There are efforts to build communal palm oil, palm oil agroforestry, and replanting palm oil plantations on the same land that can be an alternative to reduce indirect deforestation in the future.

The case of indirect deforestation in Dusun Tonggong needs to be concerned. This study shows that indirect deforestation can occur not only due to zero-deforestation commitments but also due to local people's choices to diversify incomes. This can happen by combining new commodities such as oil palm plantations and local agricultural systems such as *ladang*. Such choices are made as a defense for local communities against global market uncertainty, which is always identic with commercial commodities such as palm oil.

This study has limitations in assessing the effectiveness of the alternative practice to reduce indirect deforestation, so further studies are needed to discuss future efforts to tackle indirect deforestation.

REFERENCES

Angelsen, A. (1995). Shifting cultivation and "deforestation": a study from Indonesia. *World Development*, *23*(10), 1713-1729.

Arima, E. Y., Richards, P., Walker, R., & Caldas, M. M. (2011). Statistical confirmation of indirect land use change in the Brazilian Amazon. *Environmental Research Letters*, *6*(2), 024010.

Ayompe, L. M., Schaafsma, M., & Egoh, B. N. (2021). Towards sustainable palm oil production: The positive and negative impacts on ecosystem services and human wellbeing. *Journal of cleaner production*, *278*, 123914.

Austin, K., Alisjahbana, A., Darusman, T., Boediono, R., Budianto, B. E., Purba, C., ... & Stolle, F. (2014). Indonesia's forest moratorium: Impacts and next steps. *World Resources Institute, Washington, DC*.

Amanze, J. O., Ezeh, C. I., Okoronkwo, M. O., & ONWUJIOBI, C. (2017). Pattern of income diversification strategies among rural farmers in Nnewi North Local Government Area of Anambra State. *Journal of Sustainable Development*, *10*(2), 59-67.

Austin, K. G., Harris, N. L., Wijaya, A., Murdiyarso, D., Harvey, T., Stolle, F., & Kasibhatla, P. S. (2018). A review of land-based greenhouse gas flux estimates in Indonesia. *Environmental Research Letters*, *13*(5), 055003.

Abdoellah, O. S. (2021). *Agroforestri & Pembangunan Perdesaan Berkelanjutan di Indonesia Aspek & Prospeknya*. Jakarta: PT Gramedia Pustaka Utama.

Bai, X., Yan, H., Pan, L., & Huang, H. Q. (2015). Multi-agent modeling and simulation of farmland use change in a farming–pastoral zone: A case study of qianjingou town in inner mongolia, china. *Sustainability*, *7*(11), 14802-14833.

Barber, C. V. (1998). Forest resource scarcity & social conflict in Indonesia. *Environment: Science and Policy for Sustainable Development*, *40*(4), 4-9.

Bousquet, F., & Le Page, C. (2004). Multi-agent simulations and ecosystem management: a review. *Ecological modelling*, *176*(3-4), 313-332.

Budidarsono, S., Susanti, A., & Zoomers, A. (2013). Oil palm plantations in Indonesia: The implications for migration, settlement/resettlement and local economic development. *Biofuels-economy, environment and sustainability*, 173-193.

Clawson, M., & Stewart, C. L. (1965). Land use information. A critical survey of US statistics including possibilities for greater uniformity. *Land use information. A critical survey of US statistics including possibilities for greater uniformity*.

Chutubtim, P. (2001). *Guidelines for conducting extended cost-benefit analysis of dam projects in Thailand*. EEPSEA, Singapore, SG.

Cardenas, J. C. (2004). Norms from outside and from inside: an experimental analysis on the governance of local ecosystems. *Forest Policy and Economics*, *6*(3-4), 229-241.

Cahyandito, M. F., & Ramadhan, R. (2015). Is converting shrub land to palm oil plantation worth it?-an ecosystem services analysis. *Journal of Business and Retail Management Research*, *10*(1).

Chukwukere, A. O., & Baharuddin, A. H. (2012). Risk and poverty in agriculture: Expanding roles for agricultural cooperatives in Malaysia. *Geografia. Malaysian Journal of Society and Space*, *8*(4), 1-11.

Cramb, R. A. (2013). Palmed off: incentive problems with joint-venture schemes for oil palm development on customary land. *World Development*, *43*, 84-99.

Colchester, M., Jiwan, N., Andiko, M. S., Firdaus, A. Y., Surambo, A., & Pane, H. (2007). *Promised land: palm oil and land acquisition in Indonesia: implications for local communities and indigenous peoples*. Bogor, Indonesia: Perkumpulan Sawit Watch.

Córdoba, D., Juen, L., Selfa, T., Peredo, A. M., de Assis Montag, L. F., Sombra, D., & Santos, M. P. D. (2019). Understanding local perceptions of the impacts of large-scale oil palm plantations on ecosystem services in the Brazilian Amazon. *Forest Policy and Economics*, *109*, 102007.

Chowdhury, M., Hasan, M. E., & Abdullah-Al-Mamun, M. M. (2020). Land use/land cover change assessment of Halda watershed using remote sensing and GIS. *The Egyptian Journal of Remote Sensing and Space Science*, *23*(1), 63-75.

Chalil, D., & Barus, R. (2020). Is certification an effective tool to improve smallholdings' performance?. In *E3S Web of Conferences* (Vol. 211, p. 05004). EDP Sciences.

Darmanto, S. A., & Setyowati, A. B. (2012). Berebut Hutan Siberut (Orang Mentawai, Kekuasaan, dan Politik Ekologi). *Jakarta (ID): KPG (Kepustakaan Populer Gramedia)*.

Dharmawan, A. H., Putri, E. I. K., & Mardiyaningsih, D. I. (2016). Smallholder farmers' resilience in rural-ecological crises: studi case from West Java, Indonesia. *The International Journal of Sustainability in Economic, Social and Cultural Context*, *12*(3), 17-34.

De Man, R., & German, L. (2017). Certifying the sustainability of biofuels: Promise and reality. *Energy Policy*, *109*, 871-883.

Dislich, C., Keyel, A. C., Salecker, J., Kisel, Y., Meyer, K. M., Auliya, M., ... & Wiegand, K. (2017). A review of the ecosystem functions in oil palm plantations, using forests as a reference system. *Biological Reviews*, *92*(3), 1539-1569.

Daioglou, Vassilis, et al. "Progress and barriers in understanding and preventing indirect land-use change." *Biofuels, Bioproducts and Biorefining* 14.5 (2020): 924-934.

Davis, K. F., Dalin, C., DeFries, R., Galloway, J. N., Leach, A. M., & Mueller, N. D. (2019). Sustainable pathways for meeting future food demand. *Encyclopedia of Food Security and Sustainability,* 14-20

Dharmawan, A. H., Mardiyaningsih, D. I., Komarudin, H., Ghazoul, J., Pacheco, P., & Rahmadian, F. (2020). Dynamics of Rural Economy: A Socio-Economic Understanding of Oil Palm Expansion and Landscape Changes in East Kalimantan, Indonesia. *Land*, 213.

Ellis, F. (2000). The Determinants of Rural Livelihood Diversification in Developing Countries. *Journa of Agricultural Economics*, 289-302.

Euler, M., Krishna, V., Schwarze, S., Siregar, H., & Qaim, M. (2017). Oil palm adoption, household welfare, and nutrition among smallholder farmers in Indonesia. *World Development*, *93*, 219-235.

Fisher, I. (1930). *Theory of interest: as determined by impatience to spend income and opportunity to invest it*. Augustusm Kelly Publishers, Clifton.

Fox, J., Truong, D. M., Rambo, A. T., Tuyen, N. P., Cuc, L. T., & Leisz, S. (2000). Shifting cultivation: a new old paradigm for managing tropical forests. *BioScience*, *50*(6), 521-528.

Fahrudin, A. (2003). *Extended cost benefit analysis of present and future use of Indonesian coral reefs* (Doctoral dissertation).

Feintrenie, L., Chong, W. K., & Levang, P. (2010). Why do farmers prefer oil palm? Lessons learnt from Bungo district, Indonesia. *Small-scale forestry*, *9*(3), 379-396.

Foster, W. A., Snaddon, J. L., Turner, E. C., Fayle, T. M., Cockerill, T. D., Ellwood, M. F., ... & Yusah, K. M. (2011). Establishing the evidence base for maintaining biodiversity and ecosystem function in the oil palm landscapes of South East Asia. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *366*(1582), 3277-3291.

Fuller, C., Ondei, S., Brook, B. W., & Buettel, J. C. (2019). First, do no harm: A systematic review of deforestation spillovers from protected areas. Global Ecology and Conservation, 18, e00591. https://doi.org/10.1016/j.gecco.2019.e00591

Grube, J. W., Mayton, D. M., & Ball-Rokeach, S. J. (1994). Inducing change in values, attitudes, and behaviors: Belief system theory and the method of value self-confrontation. *Journal of social issues*, *50*(4), 153-173.

Gibbs, H. K., Ruesch, A. S., Achard, F., Clayton, M. K., Holmgren, P., Ramankutty, N., & Foley, J. A. (2010). Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. *Proceedings of the National Academy of Sciences*, *107*(38), 16732-16737.

Gillespie, P. (2011). How does legislation affect oil palm smallholders in the Sanggau district of Kalimantan, Indonesia?. *Australasian Journal of Natural Resources Law and Policy*, *14*(1), 1-37.

Gingold, B., Stolle, F., Douard, P., Rosenbarger, A., Muliastra, Y. I. K. D., Sudana, I. M., ... & Madusari, C. C. (2012). How to identify degraded land for sustainable palm oil in Indonesia.

Gunarso, P., Hartoyo, M. E., Agus, F., & Killeen, T. J. (2013). Oil palm and land use change in Indonesia, Malaysia and Papua New Guinea. *Reports from the Technical Panels of the 2nd greenhouse gas working Group of the Roundtable on Sustainable Palm Oil (RSPO)*, *29*.

Gaveau, D. L., Sloan, S., Molidena, E., Yaen, H., Sheil, D., Abram, N. K., ... & Meijaard, E. (2014). Four decades of forest persistence, clearance and logging on Borneo. *PloS ONE*, *9*(7), e101654.

Global Green Growth Institute. (2014). *Extended Cost Benefit Analysis Scoping Paper*. http://greengrowth.bappenas.go.id/wp content/uploads/2018/05/20151021120010.eCBA_Methodology_Paper.pdf

Gibbs, H. K., Rausch, L., Munger, J., Schelly, I., Morton, D. C., Noojipady, P., ... & Walker, N. F. (2015). Brazil's soy moratorium. *Science*, *347*(6220), 377-378.

Gaveau, D. L., Sheil, D., Salim, M. A., Arjasakusuma, S., Ancrenaz, M., Pacheco, P., & Meijaard, E. (2016). Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo. *Scientific reports*, *6*(1), 1-13.

Gollnow, F., Hissa, L. D. B. V., Rufin, P., & Lakes, T. (2018). Property-level direct and indirect deforestation for soybean production in the Amazon region of Mato Grosso, Brazil. *Land use policy*, *78*, 377-385.

Gatto, M., Wollni, M., & Qaim, M. (2015). Oil palm boom and land-use dynamics in Indonesia: the role of policies and socioeconomic factors. *Land Use Policy*, 292-303.

Gatti, R. C., Liang, J., Velichevskaya, A., & Zhou, M. (2019). Sustainable palm oil may not be so sustainable. *Science of the Total Environment*, *652*, 48-51.

Gatti, R. C., & Velichevskaya, A. (2020). Certified "sustainable" palm oil took the place of endangered Bornean and Sumatran large mammals habitat and tropical forests in the last 30 years. *Science of The Total Environment*, *742*, 140712.

Hardin, G. (1968). The tragedy of the commons. Hardin and Baden (eds) Managing the Commons.

Hayami, Y. (2010). Plantations agriculture. *Handbook of agricultural economics*, *4*, 3305-3322.

Hosonuma, N., Herold, M., De Sy, V., De Fries, R. S., Brockhaus, M., Verchot, L., ... & Romijn, E. (2012). An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters*, *7*(4), 044009.

Hribar, M. Š., & Lozej, Š. L. (2013). The role of identifying and managing cultural values in rural development. *Acta geographica Slovenica*, *53*(2), 371-378.

Hidayat, K. N., Glasbergen, P., & Offermans, A. (2015). Sustainability certification and palm oil smallholders' livelihood: a comparison between scheme smallholders and independent smallholders in Indonesia. *International Food and Agribusiness Management Review*, *18*(1030-2016-83041), 25-48.

Heilmayr, R., & Lambin, E. F. (2016). Impacts of nonstate, market-driven governance on Chilean forests. *Proceedings of the National Academy of Sciences*, *113*(11), 2910-2915.

Janssen, M. A., & Ostrom, E. (2006). Empirically based, agent-based models. *Ecology and society*, *11*(2).

Jiang, B., & Yao, X. (2010). Geospatial analysis and modeling of urban structure and dynamics: An overview. *Geospatial analysis and modelling of urban structure and dynamics*, 3-11.

Kummer, D. M. (1992). *Deforestation in the postwar Philippines* (No. 234). University of Chicago Press.

Kumar, V., Wankhede, K. G., & Gena, H. C. (2015). Role of cooperatives in improving livelihood of farmers on sustainable basis. *American Journal of Educational Research*, *3*(10), 1258-1266

Koh, L. P., & Wilcove, D. S. (2008). Is oil palm agriculture really destroying tropical biodiversity?. *Conservation letters*, *1*(2), 60-64.

Koh, L. P., Miettinen, J., Liew, S. C., & Ghazoul, J. (2011). Remotely sensed evidence of tropical peatland conversion to oil palm. *Proceedings of the National Academy of Sciences*, *108*(12), 5127-5132.

Khanna, M., & Crago, C. L. (2012). Measuring indirect land use change with biofuels: implications for policy. *Annu. Rev. Resour. Econ.*, *4*(1), 161-184.

Lambin, E. F., Gibbs, H. K., Heilmayr, R., Carlson, K. M., Fleck, L. C., Garrett, R. D., ... & Walker, N. F. (2018). The role of supply-chain initiatives in reducing deforestation. *Nature Climate Change*, *8*(2), 109-116.

Marten, G. G. (2001). *Human ecology: Basic concepts for sustainable development*. Earthscan.

Matthews, R. B., Gilbert, N. G., Roach, A., Polhill, J. G., & Gotts, N. M. (2007). Agent-based land-use models: a review of applications. *Landscape Ecology*, *22*(10), 1447-1459.

Morse, J. M. (1991). Approaches to qualitative-quantitative methodological triangulation. *Nursing research*, *40*(2), 120-123.

McCarthy, J. F. (2010). Processes of inclusion and adverse incorporation: oil palm and agrarian change in Sumatra, Indonesia. *The Journal of peasant studies*, *37*(4), 821-850.

Mathews, J. A., & Tan, H. (2009). Biofuels and indirect land use change effects: the debate continues. *Biofuels, Bioproducts and Biorefining*, *3*(3), 305-317.

Macedo, M. N., DeFries, R. S., Morton, D. C., Stickler, C. M., Galford, G. L., & Shimabukuro, Y. E. (2012). Decoupling of deforestation and soy production in the southern Amazon during the late 2000s. *Proceedings of the National Academy of Sciences*, *109*(4), 1341-1346.

Margono, B. A., Potapov, P. V., Turubanova, S., Stolle, F., & Hansen, M. C. (2014). Primary forest cover loss in Indonesia over 2000–2012. *Nature climate change*, *4*(8), 730-735.

Martin, S. M., & Lorenzen, K. (2016). Livelihood Diversification in Rural Laos. *World Development*, 231-243.

Mosnier, A., Boere, E., Reumann, A., Yowargana, P., Pirker, J., Havlík, P., & Pacheco, P. (2017). *Palm oil and likely futures: Assessing the potential impacts of zero deforestation commitments and a moratorium on large-scale oil palm plantations in Indonesia* (Vol. 177). CIFOR.

Meijaard, E., Garcia-Ulloa, J., Sheil, D., Wich, S. A., Carlson, K. M., Juffe-Bignoli, D., & Brooks, T. M. (2018). Oil palm and biodiversity. *A situation analysis by the IUCN Oil Palm Task Force*.

Meijaard, E., Brooks, T. M., Carlson, K. M., Slade, E. M., Garcia-Ulloa, J., Gaveau, D. L., ... & Sheil, D. (2020). The environmental impacts of palm oil in context. *Nature plants*, *6*(12), 1418-1426.

Namany, S., Govindan, R., Alfagih, L., McKay, G., & Al-Ansari, T. (2020). Sustainable food security decision-making: an agent-based modelling approach. *Journal of Cleaner Production*, *255*, 120296.

Nelson, G. C., & Geoghegan, J. (2002). Deforestation and land use change: sparse data environments. *Agricultural Economics*, *27*(3), 201-216.

Nelson, P. N., Gabriel, J., Filer, C., Banabas, M., Sayer, J. A., Curry, G. N., ... & Venter, O. (2014). Oil palm and deforestation in Papua New Guinea. *Conservation Letters*, *7*(3), 188-195.

Newton, P., & Benzeev, R. (2018). The role of zero-deforestation commitments in protecting and enhancing rural livelihoods. *Current Opinion in Environmental Sustainability*, *32*, 126-133.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge university press.

Powell, P. T. (1998). Traditional production, communal land tenure, and policies for environmental preservation in the South Pacific. *Ecological Economics*, *24*(1), 89-101.

Parker, D. C., Manson, S. M., Janssen, M. A., Hoffmann, M. J., & Deadman, P. (2003). Multi-agent systems for the simulation of land-use and land-cover change: a review. *Annals of the association of American Geographers*, *93*(2), 314-337.

Parker, D. C., Brown, D. G., Polhill, J. G., Deadman, P. J., & Manson, S. M. (2008). Illustrating a new'conceptual design pattern'for agent-based models of land use via five case studies—the MR POTATOHEAD framework. Universidad de Valladolid.

Pareira, S. P. I. (2021). Roundtable on Sustainable Palm Oil (RSPO) certification in Indonesia: a complex case of global environmental governance.

Prabowo, D., Maryudi, A., & Imron, M. A. (2017). Conversion of forests into oil palm plantations in West Kalimantan, Indonesia: Insights from actors' power and its dynamics. *Forest Policy and Economics*, *78*, 32-39.

Rokeach, M. (1968). A theory of organization and change within value-attitude systems. *Journal of Social Issues*, 13-33.

Roberti, M. (1989). Agribusiness: Asia's next economic miracle. *Asian Finance*, *15*(7), 54-56.

Robinson, D. T., Brown, D. G., Parker, D. C., Schreinemachers, P., Janssen, M. A., Huigen, M., ... & Barnaud, C. (2007). Comparison of empirical methods for building agent-based models in land use science. *Journal of land use science*, *2*(1), 31-55.

Ruysschaert, D., & Salles, D. (2014). Towards global voluntary standards: Questioning the effectiveness in attaining conservation goals: The case of the Roundtable on Sustainable Palm Oil (RSPO). *Ecological Economics*, *107*, 438-446.

Rausch, L. L., & Gibbs, H. K. (2016). Property arrangements and soy governance in the Brazilian state of Mato Grosso: Implications for deforestation-free production. *Land*, *5*(2), 7.

Ruysschaert, D., & Salles, D. (2018). The strategies and effectiveness of conservation NGOs in the global voluntary standards: The case of the Roundtable on Sustainable Palm Oil. In *The Anthropology of Conservation NGOs* (pp. 121-149). Palgrave Macmillan, Cham.

Sauer, C. O. (1919). Mapping the Utilization of the Land. *Geographical review*, *8*(1), 47-54.

Sunderlin, W. D., & Resosudarmo, I. A. P. (1996). *Rates and causes of deforestation in Indonesia: towards a resolution of the ambiguities* (pp. 1-3). Bogor: CIFOR.

Schaafsma, M., & Brouwer, R. (2006). Overview of existing guidelines and manuals for the economic valuation of environmental and resource costs and benefits. *Unpublished AquaMoney Report, Institute for Environmental Studies (IVM), Vrije Universiteit Amsterdam. Avalilable at www. aquamoney. org*.

Siebert, R., Toogood, M., & Knierim, A. (2006). Factors affecting European farmers' participation in biodiversity policies. *Sociologia ruralis*, *46*(4), 318-340.

Sumiani, Y., Haslinda, Y., & Lehman, G. (2007). Environmental reporting in a developing country: a case study on status and implementation in Malaysia. *Journal of cleaner production*, *15*(10), 895-901.

Searchinger, T., Heimlich, R., Houghton, R. A., Dong, F., Elobeid, A., Fabiosa, J., ... & Yu, T. H. (2008). Use of US croplands for biofuels increases greenhouse gases through emissions from land-use change. *Science*, *319*(5867), 1238-1240.

Sirait, M. T. (2009). *Indigenous Peoples and Oil Palm Plantation Expansion in West Kalimantan, Indonesia*. Amsterdam: Cordaid.

Savilaakso, S., Garcia, C., Garcia-Ulloa, J., Ghazoul, J., Groom, M., Guariguata, M. R., ... & Zrust, M. (2014). Systematic review of effects on biodiversity from oil palm production. *Environmental Evidence*, *3*(1), 1-21.

Schmidt, J. H., Weidema, B. P., & Brandão, M. (2015). A framework for modelling indirect land use changes in life cycle assessment. *Journal of Cleaner Production*, *99*, 230-238.

Schoneveld, G. C., Ekowati, D., Andrianto, A., & Van Der Haar, S. (2019). Modeling peat-and forestland conversion by oil palm smallholders in Indonesian Borneo. *Environmental Research Letters*, *14*(1), 014006.

Santika, T., Wilson, K. A., Meijaard, E., Budiharta, S., Law, E. E., Sabri, M., ... & Poh, T. M. (2019). Changing landscapes, livelihoods and village welfare in the context of oil palm development. *Land Use Policy*, *87*, 104073.

Savari, M., & Shokati Amghani, M. (2021). Factors influencing farmers' adaptation strategies in confronting the drought in Iran. *Environment, Development and Sustainability*, *23*(4), 4949-4972.

Sokhannaro, H. E. P. (2011) 'Oil palm development in Cambodia', in M. Colchester and S. Chao (eds) Oil Palm Expansion in Southeast Asia: Trends and Implications for Local Communities and Indigenous Peoples. Moreton-in-Marsh: Forest Peoples Programme, pp. 52–78.

Toumbourou, T. D., & Dressler, W. H. (2020). Sustaining livelihoods in a palm oil enclave: Differentiated gendered responses in East Kalimantan, Indonesia. *Asia Pacific Viewpoint*.

USGS, 2020. Common Landsat Band RGB Composites.https://www.usgs.gov/faqs/what-are-best-landsat-spectral-bands-use-my-research?qt-news_science_products=0#qt-news_science_products (accessed March.21.20).

Vermeulen, S., & Goad, N. (2006). *Towards better practice in smallholder palm oil production*. Iied.

Valbuena, D., Verburg, P. H., Bregt, A. K., & Ligtenberg, A. (2010). An agent-based approach to model land-use change at a regional scale. *Landscape ecology*, *25*(2), 185-199.

Vijay, V., Pimm, S. L., Jenkins, C. N., & Smith, S. J. (2016). The impacts of oil palm on recent deforestation and biodiversity loss. *PloS one*, *11*(7), e0159668.

Wu, J. (2008). Land use changes: Economic, social, and environmental impacts. *Choices*, *23*(4), 6-10.

Wicke, B., Sikkema, R., Dornburg, V., Junginger, M., & Faaij, A. (2008). Drivers of land use change and the role of palm oil production in Indonesia and Malaysia. *Overview of past developments and future projections. Copernicus Institute Science, Universiteit Utrecht, Utrecht, The Netherlands.*

Wiggins, S., Kirsten, J., & Llambí, L. (2010). The future of small farms. *World development*, *38*(10), 1341-1348.

Zahar, Z., Colin, B., Ria, G., & John, F. M. (2016). *The oil palm complex smallholders, agribusiness and the state in Indonesia and Malaysia* (Rob, C., & John, F. M., Ed.). NUS Press

APPENDIX

Table A1

Financial Cost Benefit Analysis

Total Value (Rp/Ha)	Year												
	0-3	4	5	6	7	8	9	10-20	21	22	23	24	25
Costs													
Total Investment Cost/Ha[a]	7,212,703	1,596,057	1,148,539										
Total Production Cost/Ha[b]	0	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000
Benefit													
Total Return from Fresh Fruit Bunch (FFB)/Ha[c]	0	15324000	16500000	17052000	17688000	16896000	18744000	19380000	19008000	18888000	18048000	17628000	17088000
Net Profit	-7,212,703	47,943	1,671,461	3,372,000	4,008,000	3,216,000	5,064,000	5,700,000	5,328,000	5,208,000	4,368,000	3,948,000	3,408,000

Analysis	Discount Rate		
	10%	8%	4%
NPV Value	IDR26,043,382	IDR33,146,990	IDR54,978,976
IRR	37%	37%	37%
B/C Ratio	5.0	6.0	8.9

[a] Total Investment in 5 Years – including Plant and No-Plant Investment (Data source: Financial Report PTPN XIII 2012-2013.

[b] Total Production Cost start from the fourth year – including Operational and Maintenance cost (Data source: Financial Report PTPN XIII 2012-2013)

[c] Price of Fresh Fruit Bunch (Data source: http://disbun.kalbarprov.go.id/index.php/informasi-harga/kelapa-sawit/226-harga-produk-kelapa-sawit-tahun-2018)

Table A2

Extended Cost Benefit Analysis Scheme A

Total Value (Rp/Ha)	Year												
	0-3	4	5	6	7	8	9	10-20	21	22	23	24	25
Costs													
Total Investment Cost/Ha[a]	7,212,703	1,596,057	1,148,539										
Total Production Cost/Ha[b]	0	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000
Environmental Cost/Ha[c]	1,815,896	1,558,079	1,558,079	1,558,079	1,558,079	1,558,079	1,558,079	1,558,079	1,558,079	1,558,079	1,558,079	1,558,079	1,558,079
Benefit													
Total Return from Fresh Fruit Bunch (FFB)/Ha[d]	0	15324000	16500000	17052000	17688000	16896000	18744000	19380000	19008000	18888000	18048000	17628000	17088000
Net Profit	-9,028,599	-1,510,136	113,382	1,813,921	2,449,921	1,657,921	3,505,921	4,141,921	3,769,921	3,649,921	2,809,921	2,389,921	1,849,921

Analysis	Discount Rate		
	10%	8%	4%
NPV Value	IDR11,968,247	IDR16,749,341	IDR31,582,942
IRR	20%	20%	20%
B/C Ratio	2.3	2.7	4.1

[a] Total Investment in 5 Years – including Plant and No-Plant Investment (Data source: Financial Report PTPN XIII 2012-2013).

[b] Total Production Cost start from the fourth year – including Operational and Maintenance cost (Data source: Financial Report PTPN XIII 2012-2013)

[c] Environmental Cost – including Provisioning Food, Recreation – lowest value of pest control and LCC (Data source: Cahyandito & Ramadhan, 2015; PTPN XIII Document for the value of LCC & Leaf midrib)

[d] Price of Fresh Fruit Bunch (Data source: http://disbun.kalbarprov.go.id/index.php/informasi-harga/kelapa-sawit/226-harga-produk-kelapa-sawit-tahun-2018)

Table A3

Extended Cost Benefit Analysis Scheme B

Total Value (Rp/Ha)	Year												
	0-3	4	5	6	7	8	9	10-20	21	22	23	24	25
Costs													
Total Investment Cost/Ha[a]	7,212,703	1,596,057	1,148,539										
Total Production Cost/Ha[b]	0	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000
Environmental Cost/Ha[c]	1,815,916	1,558,098	1,558,098	1,558,098	1,558,098	1,558,098	1,558,098	1,558,098	1,558,098	1,558,098	1,558,098	1,558,098	1,558,098
Benefit													
Total Return from Fresh Fruit Bunch (FFB)/Ha[d]	0	15324000	16500000	17052000	17688000	16896000	18744000	19380000	19008000	18888000	18048000	17628000	17088000
Net Profit	-9,028,619	-1,510,155	113,363	1,813,902	2,449,902	1,657,902	3,505,902	4,141,902	3,769,902	3,649,902	2,809,902	2,389,902	1,849,902

Analysis	Discount Rate		
	10%	8%	4%
NPV Value	IDR11,968,077	IDR16,749,143	IDR31,582,659
IRR	20%	20%	20%
B/C Ratio	2.3	2.7	4.1

[a] Total Investment in 5 Years – including Plant and No-Plant Investment (Data source: Financial Report PTPN XIII 2012-2013).

[b] Total Production Cost start from the fourth year – including Operational and Maintenance cost (Data source: Financial Report PTPN XIII 2012-2013)

[c] Environmental Cost – including Provisioning Food, Recreation – highest value of pest control and LCC (Data source: Cahyandito & Ramadhan, 2015; PTPN XIII Document for the value of LCC & Leaf midrib)

[d] Price of Fresh Fruit Bunch (Data source: http://disbun.kalbarprov.go.id/index.php/informasi-harga/kelapa-sawit/226-harga-produk-kelapa-sawit-tahun-2018)

Table A4

Extended Cost Benefit Analysis Scheme C

Total Value (Rp/Ha)	**Year**												
	0-3	**4**	**5**	**6**	**7**	**8**	**9**	**10-20**	**21**	**22**	**23**	**24**	**25**
Costs													
Total Investment Cost/Ha[a]	7,212,703	1,596,057	1,148,539										
Total Production Cost/Ha[b]	0	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000
Environmental Cost/Ha[c]	991,121	991,121	991,121	991,121	991,121	991,121	991,121	991,121	991,121	991,121	991,121	991,121	991,121
Benefit													
Total Rerturn from Fresh Fruit Bunch (FFB)/Ha[d]	0	15324000	16500000	17052000	17688000	16896000	18744000	19380000	19008000	18888000	18048000	17628000	17088000
Net Profit	-8,203,824	-943,178	680,340	2,380,879	3,016,879	2,224,879	4,072,879	4,708,879	4,336,879	4,216,879	3,376,879	2,956,879	2,416,879

Analysis	**Discount Rate**		
	10%	**8%**	**4%**
NPV Value	IDR17,239,038	IDR22,868,016	IDR40,254,048
IRR	26%	26%	26%
B/C Ratio	3.1	3.7	5.6

[a] Total Investment in 5 Years – including Plant and No-Plant Investment (Data source: Financial Report PTPN XIII 2012-2013).

[b] Total Production Cost start from the fourth year – including Operational and Maintenance cost (Data source: Financial Report PTPN XIII 2012-2013)

[c] Environmental Cost – including Provisioning Food, Recreation – lowest value of pest control and Leaf Midrib (Data source: Cahyandito & Ramadhan, 2015; PTPN XIII Document for the value of LCC & Leaf midrib)

[d] Price of Fresh Fruit Bunch (Data source: http://disbun.kalbarprov.go.id/index.php/informasi-harga/kelapa-sawit/226-harga-produk-kelapa-sawit-tahun-2018)

Table A5

Extended Cost Benefit Analysis Scheme D

Total Value (Rp/Ha)	Year												
	0-3	4	5	6	7	8	9	10-20	21	22	23	24	25
Costs													
Total Investment Cost/Ha[a]	7,212,703	1,596,057	1,148,539										
Total Production Cost/Ha[b]	0	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000
Environmental Cost/Ha[c]	991,141	991,141	991,141	991,141	991,141	991,141	991,141	991,141	991,141	991,141	991,141	991,141	991,141
Benefit													
Total Rerturn from Fresh Fruit Bunch (FFB)/Ha[d]	0	15324000	16500000	17052000	17688000	16896000	18744000	19380000	19008000	18888000	18048000	17628000	17088000
Net Profit	-8,203,844	-943,198	680,320	2,380,859	3,016,859	2,224,859	4,072,859	4,708,859	4,336,859	4,216,859	3,376,859	2,956,859	2,416,859

Analysis	Discount Rate		
	10%	8%	4%
NPV Value	IDR17,238,860	IDR22,867,808	IDR40,253,751
IRR	26%	26%	26%
B/C Ratio	3.1	3.7	5.6

[a] Total Investment in 5 Years – including Plant and No-Plant Investment (Data source: Financial Report PTPN XIII 2012-2013).

[b] Total Production Cost start from the fourth year – including Operational and Maintenance cost (Data source: Financial Report PTPN XIII 2012-2013)

[c] Environmental Cost – including Provisioning Food, Recreation – highest value of pest control and Leaf Midrib (Data source: Cahyandito & Ramadhan, 2015; PTPN XIII Document for the value of LCC & Leaf midrib)

[d] Price of Fresh Fruit Bunch (Data source: http://disbun.kalbarprov.go.id/index.php/informasi-harga/kelapa-sawit/226-harga-produk-kelapa-sawit-tahun-2018)

Tabel A6

Extended Cost Benefit Analysis Scheme E

Total Value (Rp/Ha)	Year												
	0-3	4	5	6	7	8	9	10-20	21	22	23	24	25
Costs													
Total Investment Cost/Ha[a]	7,212,703	1,596,057	1,148,539										
Total Production Cost/Ha[b]	0	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000
Environmental Cost/Ha[c]	1,951,590	1,693,772	1,693,772	1,693,772	1,693,772	1,693,772	1,693,772	1,693,772	1,693,772	1,693,772	1,693,772	1,693,772	1,693,772
Benefit													
Total Rerturn from Fresh Fruit Bunch (FFB)/Ha[d]	0	15324000	16500000	17052000	17688000	16896000	18744000	19380000	19008000	18888000	18048000	17628000	17088000
Net Profit	-9,164,293	-1,645,829	-22,311	1,678,228	2,314,228	1,522,228	3,370,228	4,006,228	3,634,228	3,514,228	2,674,228	2,254,228	1,714,228

Analysis	Discount Rate		
	10%	8%	4%
NPV Value	IDR10,762,855	IDR15,342,060	IDR29,566,972
IRR	19%	19%	19%
B/C Ratio	2.1	2.6	3.9

[a] Total Investment in 5 Years – including Plant and No-Plant Investment (Data source: Financial Report PTPN XIII 2012-2013).

[b] Total Production Cost start from the fourth year – including Operational and Maintenance cost (Data source: Financial Report PTPN XIII 2012-2013)

[c] Environmental Cost – including Provisioning Food, Recreation – lowest value of pest control, and combination Leaf Midrib and LCC (Data source: Cahyandito & Ramadhan, 2015; PTPN XIII Document for the value of LCC & Leaf midrib)

[d] Price of Fresh Fruit Bunch (Data source: http://disbun.kalbarprov.go.id/index.php/informasi-harga/kelapa-sawit/226-harga-produk-kelapa-sawit-tahun-2018)

Tabel A7

Extended Cost Benefit Analysis Scheme F

Total Value (Rp/Ha)	Year												
	0-3	4	5	6	7	8	9	10-20	21	22	23	24	25
Costs													
Total Investment Cost/Ha[a]	7,212,703	1,596,057	1,148,539										
Total Production Cost/Ha[b]	0	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000	13,680,000
Environmental Cost/Ha[c]	1,951,610	1,693,792	1,693,792	1,693,792	1,693,792	1,693,792	1,693,792	1,693,792	1,693,792	1,693,792	1,693,792	1,693,792	1,693,792
Benefit													
Total Return from Fresh Fruit Bunch (FFB)/Ha[d]	0	15324000	16500000	17052000	17688000	16896000	18744000	19380000	19008000	18888000	18048000	17628000	17088000
Net Profit	-9,164,313	-1,645,849	-22,331	1,678,208	2,314,208	1,522,208	3,370,208	4,006,208	3,634,208	3,514,208	2,674,208	2,254,208	1,714,208

Analysis	Discount Rate		
	10%	8%	4%
NPV Value	IDR10,762,678	IDR15,341,853	IDR29,566,675
IRR	19%	19%	19%
B/C Ratio	2.1	2.6	3.9

[a] Total Investment in 5 Years – including Plant and No-Plant Investment (Data source: Financial Report PTPN XIII 2012-2013).

[b] Total Production Cost start from the fourth year – including Operational and Maintenance cost (Data source: Financial Report PTPN XIII 2012-2013)

[c] Environmental Cost – including Provisioning Food, Recreation – highest value of pest control, and combination Leaf Midrib and LCC (Data source: Cahyandito & Ramadhan, 2015; PTPN XIII Document for the value of LCC & Leaf midrib)

[d] Price of Fresh Fruit Bunch (Data source: http://disbun.kalbarprov.go.id/index.php/informasi-harga/kelapa-sawit/226-harga-produk-kelapa-sawit-tahun-2018)