Doctoral Dissertation

A Study on Forest Permits and Deforestation in Indonesia

JAROT INDARTO

Graduate School for International Development and Cooperation
Hiroshima University

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JAROT INDARTO

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We hereby recommend that the dissertation by Mr.JAROT INDARTO entitled "A Study on Forest Permits and Deforestation in Indonesia" be accepted in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY.

Committee on Final Examination:

KANEKO Shinji, Professor
Chairperson

GOTO Daisaku, Associate Professor

KAWATA Keisuke, Associate Professor

FUJIWARA Akimasa, Professor

KAWANISHI Masato
Senior Advisor, JICA

Date: July 25, 2015

Approved:

FUJIWARA Akimasa, Professor
Dean

Date: September 4, 2015

Graduate School for International Development and Cooperation
Hiroshima University

SUMMARY

The main objective of this thesis research is to investigate the relationship between forest permits and deforestation in Indonesia. Furthermore, to better understanding their associations, roles of the Sustainable Forest Management (SFM) certification and the improvement of oil palm productivity to mitigate deforestation area also analysed. Reducing deforestation in Indonesia contributes to climate change mitigation at a globally and regionally significant scale (Busch et al. 2015). Some policies and actions have been undertaken by the government to reduce forest cover loss and greenhouse gas (GHG) emissions from forestry sector, such as the moratorium forest policy, illegal logging prevention, the preparation for reducing emissions from deforestation and forest degradation (REDD), SFM, forest and peat land fire prevention, forest land use boundary and customary enforcement, One Map Initiative, and so forth. However, deforestation in Indonesia remains high, in terms of the amount of area and rate. The Global Forest Change (GFC) or Hansen dataset (Hansen et al. 2013*a*), at which the present analysis is based on, reports that forest cover has been reduced from around 0.75 million ha in 2001 and nearly 1.18 million ha in 2005 to 2.03 million ha in 2012, or on average nearly 1.30 million ha/year during this period. The recent data from the Ministry of Forestry reports that the rate of deforestation was around 0.61 million hectares in 2011-2012 (MoF 2014*a*).

The majority of forests in Indonesia is state forest, managed under concession or permit system (Karsenty et al. 2008). Multifarious types of forest permits are issued, especially for commercial purposes. Two major permits are the logging permit (LP) for productive (high tree cover) production forest, where permitted business entities may harvest timber selectively referred as, and the plantation conversion permits (PCP) for unproductive production forest, where permitted business entities must first do planting and then harvest the timber when the planted trees are mature. In recent decades, although forest permit system has been criticized because of their damaging environmental impacts (Gautam et al. 2000; Dennis et al. 2008; Amacher et al. 2012), the causality and the association between forest permits and deforestation remain inconclusive. By expecting a positive correlation for LP and a negative association for PCP, therefore, the first analysis of this thesis is to estimate impacts of forest permits on deforestation.

Within forest permit system, global society has put a strong attention for unsustainable logging practices (Dudley et al. 1995; Sierra 2001; Gullison 2003; Damette and Delacote 2011). To counteract environmental issues surrounding timber harvesting, such SFM guidance or practices have been developed and promoted for decades (Gullison 2003; Dennis et al. 2008). Indonesia has adopted, developed and promoted SFM since 1993, in the forms of the market-driven scheme and the domestic government-established scheme. Although it has been more than two decades, the domestic SFM certification scheme has not been analysed yet. The second research topic of this thesis aims at investigating this potential mitigation of the domestic SFM certification on deforestation reduction, expecting that it can significantly reduce deforestation.

As forest resources decline, forest land will be likely to be converted to other land uses. The government has established the Convertible Forest that can be legally but limitedly converted to other non-forest land uses (such as infrastructure provision, agriculture development and mining). Forest conversion is also stimulated by other factors, especially higher rent values of other non-forest land uses. Rapid agricultural expansion, especially oil palm (Casson 2000; MoF 2008; Hansen et al. 2009), has been cited to be one of the major causes of forest conversion that bring significant pressures on forest (Margono et al. 2012; Gaveau et al. 2013; Abood et al. 2014; Lee et al. 2014*b*; Busch et al. 2015). To

mitigate deforestation in oil palm development, increasing oil palm productivity has been proposed by scholars and adopted by the government and the international development institutions (WB 2011; Miyake et al. 2012; Hoffmann et al. 2014). However, their relationships are mixed in which improved oil palm could be potential or risks for the forest. Hence, the last analysis of the thesis is to quantitatively investigate impacts of oil palm expansion and productivity on deforestation in Indonesia, expecting that oil palm expansion accelerates deforestation while oil palm productivity mitigates deforestation.

The main data of this thesis is based on the first version of GFC or Hansen dataset 2000-2012 (Hansen et al. 2013*a*). In the analysis, deforestation is measured by annual forest cover loss at current year in the period of 2000-2012. The first and the last analysis have been done with panel data at the provincial level, while the second analysis is at the forest unit level. By employing the fixed-effect estimation, the first analysis results in the insignificant sign of LP, but unfortunately PCP stimulates a greater forest cover loss. Unexpected results have also been revealed in the second analysis in which mitigating impacts of the certification of the domestic SFM on deforestation reduction cannot be robustly confirmed, but partially observed. The limited potential of this scheme is observed in the case of LP. Since the effects of the agricultural yield on deforestation is mediated through the agricultural area expansion, the Causal Mediation Analysis (Imai et al. 2010) is employed for the last analysis. Results show that both the oil palm productivity and the oil palm area have positive and significant impacts on deforestation. Approximately 54% of total effects of oil palm productivity on forest cover loss are mediated through the area expansion.

Several results of this thesis` analysis have been in consistency with other empirical studies (an insignificant association between LP and deforestation, and a positive correlation between oil palm expansion and deforestation). However, results on PCP, the domestic SFM certification and the oil palm productivity have been on the contrary with the expectation and the current policies, in which the government has established and supported PCP, SFM and oil palm productivity to be some of mitigation actions to reduce deforestation. This thesis argues that the unexpected results of PCP and oil palm productivity are mainly due to the fact that most of PCP and oil palm plantation have been established on the forested areas (Koh and Wilcove 2008; Obidzinski and Chaudhury 2009; Carlson et al. 2012*a*). Hence, suspending new permits for PCP and oil palm plantation could be a temporary alternative policy to reduce deforestation in a short-term. However, it is highly recommended for the government to reposition their current policies by emphasizing on longer-term actions, such as redefining the current criteria of unproductive and forested areas, evaluating the current implementation of PCP, the oil palm plantation and the domestic SFM, and directing and incentivizing the development of oil palm on unproductive and non-forested areas. In sum, this thesis concludes that reducing deforestation has to take into account other non-forestry factors that potentially bring about crucial effects on deforestation.

ABBREVIATION

BPS : *Badan Pusat Statistik* (Central Statistics Agency).

C&I : Criteria and Indicator, of SFM.

EIA : Environmental Impact Assessment.

EKC : Environmental Kuznets Curve.

FAO : Food and Agriculture Organization for the United Nations.

FLEGT : Forest Law Enforcement, Governance and Trade.

FORMA : Forest Monitoring for Action database.

FRA : Forest Resource Assessment, by FAO.

FSC : Forest Stewardship Council.

GFC : Global Forest Change or Hansen database.

GHG : Greenhouse gasses.

GDP : Gross Domestic Products.

GoI : The Government of Indonesia.

GRDP : Gross Regional Domestic Products.

IFCA : Indonesian Forest Climate Alliance.

IFCC : Indonesian Forestry Certification Cooperation.

IPAT : Impacts, Population, Affluence and Technology.

ITTO : International Tropical Timber Organization.

JCP : Joint Certification Protocol, between LEI and FSC.

LEI : *Lembaga Ekolable Indonesia* (Indonesia Ecolabelling Institute).

LP : Logging Permits (*Ijin Usaha Pemanfaatan Hasil Hutan Kayu Hutan Alam – IUPHHK-HA*), permit released by the government for business entity to harvest natural timber in productive production forest areas.

MEA : Millenium Environment Assessment.

MIFEE : Merauke Integrated Food and Energy Estate Program.

MoA : Ministry of Agriculture.

MoE : Ministry of Environment.

MoF : Ministry of Forestry.

OSIRIS : Open Source Impacts of REDD Initiatives Spreadsheet database.

PCP : Plantation Conversion Permits (*Ijin Usaha Pemanfaatan Hasil Hutan Kayu Hutan Tanaman – IUPHHK-HT*), permit issued by the government for business entity to utilize unproductive/degraded forest areas for timber plantation.

PEFC : Programme for the Endorsement of Forest Certification.

REDD : Reducing Emission from Deforestation and Forest Degradation.

RIL : Reduced-Impact Logging.

SFM : Sustainable Forest Management.

STIRPAT : Stochastic Impacts of Regression on Population, Affluence and Technology.

SVLK : *Sistem Verifikasi Legalitas Kayu* (Indonesian Timber Legality Verification System).

TPTI : *Tebang Pilih Tanam Indonesia* (Indonesian Selective Felling and Planting System).

UNCED : United Nations Conference on Environment and Development.

UNFCCC : United Nations Framework Convention on Climate Change.

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CHAPTER I. GENERAL INTRODUCTION

1.1. Background

Deforestation and forest degradation have gained remarkable concerns in the climate change policy discourses. Deforestation is one of the greatest environmental crises (Ludeke et al. 1990). The losses of forest cover, which have been mostly occurred in the tropical forest countries (FAO 2010; Hansen et al. 2013*a*), have contributed as one of the primary drivers of biodiversity loss (Gibson et al. 2011) and is responsible for a significant part of global greenhouse gas (GHG) emissions (Bawa and Seidler 1998; Pimm and Raven 2000; Gullison 2003; FAO 2006; IPCC 2007; Ebeling and Yasué 2009; Venter et al. 2009; Vieilledent et al. 2013). It is projected to remain a major source of GHG emission for the foreseeable future (MEA 2005). Furthermore, deforestation is just an initial sign of further environmental crises, desertification (Geist 2005).

The rate of tropical deforestation had been declining; however, this trend has overturned (Budiharta et al. 2014). In 2000-2005, Food and Agriculture Organization (FAO 2010) reports that the global rate of deforestation is around 13 million hectares per year. A recent study counts the global forest loss approximately 230 million hectares over the period 2000-2012 or in average around 19.17 hectares per year (Hansen et al. 2013*a*). Halting global deforestation is the main key strategy to reduce global GHG emissions. Deforestation mitigation should be the most priority in the current global environmental commitment.

Globally, Brazil and Indonesia contain around 35% of the total carbon store in tropical forests. Both countries are also responsible for the largest GHG emitters from forest loss (Baccini et al. 2012). Specifically, Indonesia has been cited as the highest GHG emitter from land use (MoF 2008) and one of the largest GHG emission from forestry (Baccini et al. 2012) all over the world. At regional level, Indonesia is responsible for a large scale of the Southeast Asia deforestation and GHG emissions (van Noordwijk et al. 2013).

At national level, indeed, approximately 62% of national GHG emissions are attributed to the forestry sector (MoE 2010). As depicted in Table 1 considering this fact, the government has set the target in which GHG emission reduction from forestry sector contains more than 80% of total GHG emissions reductions (GoI 2011).

Table 1. Sources of GHG emissions and target of GHG emission reduction by sectors (Source: GoI 2011)

Sector	GHG emissions	Target of GHG emission reduction by 220	
		26% reduction	41% reduction
Forest and peat	62.0%	87.6%	87.4%
Agriculture	5.0%	1.1%	0.9%
Energy and transportation	22.0%	5.1%	4.8%
Industry	2.0%	1.2%	0.5%
Waste	9.0%	6.0%	6.4%
Total	100.0%	100.0%	100.0%

Deforestation in Indonesia remains high, in terms of the amount of area and rate. During the period of 2000-2005, FAO reports that forest cover loss in Indonesia was around 1.9 million ha per year (FAO 2006); whereas, IFCA report (MoF 2008) this value was around 1.04 million ha with an increasing trend. The Ministry of Environment announces a higher level of this rate, approximately 1.10 million hectares per year from 2000 to 2005 (MoE 2010).

Annual Forestry Statistics by the Ministry of Forestry also reports the estimation of deforestation. It was approximately 1.2 million ha/year for the period 2003-2006, around 0.8 million ha/year for 2006-2009, and nearly 0.5 million in 2009-2011 and for 2005-2010. In the period of 2005-2010, FAO (FAO 2010) estimates deforestation decreased to be nearly 0.7 million ha/year. Meanwhile, based on OSIRIS database (Busch et al. 2012), its average value was reported around 0.7 million ha/year.

The Global Forest Change (GFC) or Hansen dataset, at which the analysis of this chapter is based on, brings a recent and more detail estimation of deforestation. Based on this, Indonesia has experienced an increasing trend of forest cover loss during 2001-2012. Forest cover has been reduced from around 0.75 million ha in 2001 and nearly 1.18 million ha in 2005 to 2.03 million ha in 2012 (Figure 1), or on average nearly 1.30 million ha/year during this period. The recent data from the Ministry of Forestry reports that the rate of deforestation was around 0.61 million hectares in 2011-2012 (MoF 2014*a*). In more detail, Margono *et al.* (2014) further calculates that nearly 0.84 million hectares of primary forests were lost annually by 2012. Reducing deforestation in Indonesia can contribute to climate change mitigation at a globally and regionally significant scale (Busch et al. 2015). Indonesia's GHG emission reduction depends heavily on the mitigation of deforestation (Hunt 2010).

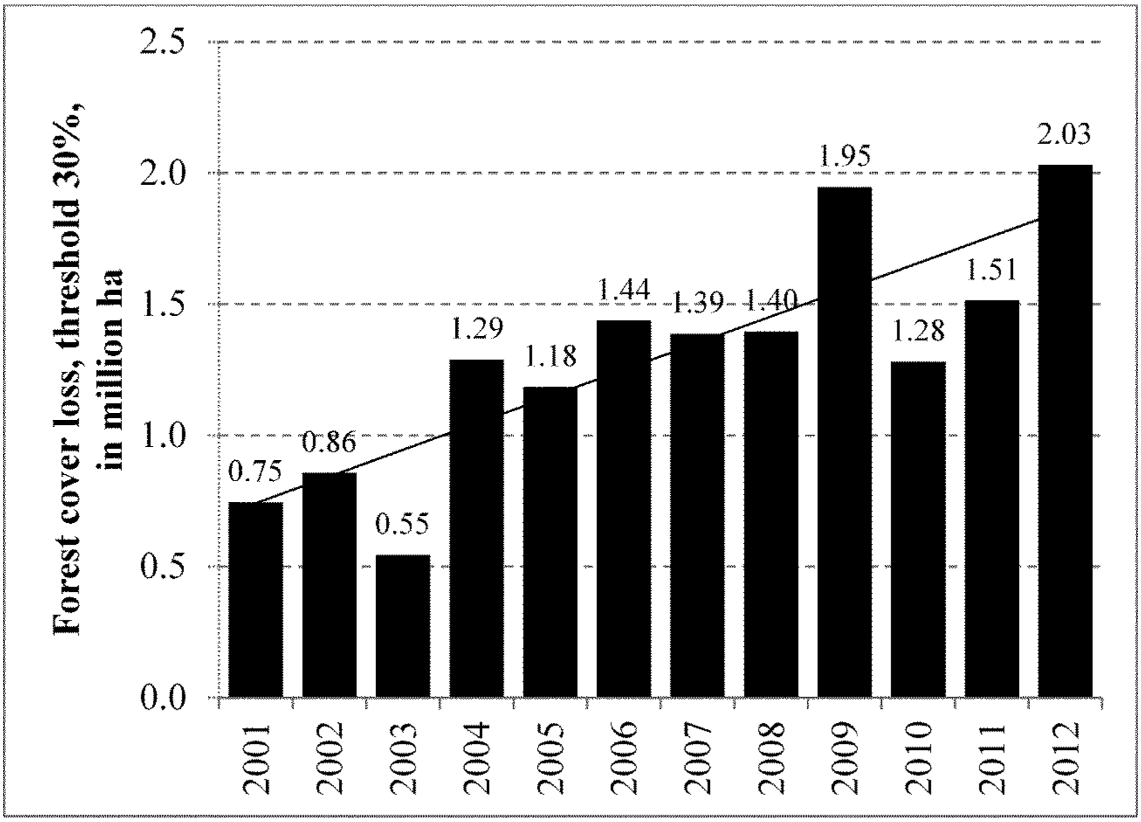


Figure 1. Annual forest cover loss (threshold 30% of canopy cover), in million ha, 2001-2012 (Source: analysed from Hansen et al. (2013b); note: the straight line is the fitted linear trendline of forest cover loss)

Some policies and actions have been undertaken by the government to reduce GHG emissions from forestry sector. In the Presidential Instruction Number 61 Year 2011 (GoI 2011), the government accentuates some national strategies, including forest and peat land fire prevention, illegal logging prevention, and sustainable forest management (SFM) enhancement. Furthermore, strengthening forest land use boundary and customary has been strengthened to prevent forest conversion. One Map Initiative has been developed to clarify land ownership and concession boundary (Anderson 2013). With regard to prevent conversion, Indonesia has strongly committed to develop and support REDD (reducing emissions from deforestation and forest degradation) initiative, an incentive mechanism to maintain forest. To protect forests, protected and conservation forests have also been extended, in which both forests have increased from approximately 52.3 million ha in 2001 to nearly 57.6 million ha in 2012. Improving the sustainable forest practices (selective logging, reduced-impact logging (RIL), forest certification, and silviculture technique) have been promoted to reduce GHG emissions during logging activities (MoF 2011; Molnar et al. 2011). RIL adoption, for example, offers the opportunity to reduce CO_2 emissions by 30 to 50% across tropical forests (Griscom *et al.* 2014).

In addition to those GHG emission reduction-related policies, since 2011, the government has enacted a more stringent policy, the forest moratorium policy stipulated in the Presidential Instruction Number 10 Year 2011 on the postponement of issuance of new licenses and the improvement governance in natural forest and peatland, and extended by Presidential Instruction Number 6 Year 2013. Under the first policy, the government has suspended new LP in natural forest to prevent forest degradation and in peat land to avoid deforestation. It is regarded as a key element of Indonesia's climate change strategy (Anderson 2013) and the most significant REDD initiative (Margono et al. 2012). Recently, through the establishment of Government Regulation Number 12 Year 2014 on the types and the level of fee tariff for forestry sector or the forest tariff policy (GoI 2014), the government has established new fee structure that had not been changed since 1998/1999. Under this new policy, the government has put more restrictions for business entities to access productive production forest by increasing the license fee and the provision fee for LP. Meanwhile, in the same policy, in addition to current incentives (Bull et al. 2006; Obidzinski and Chaudhury 2009), the government reduces those fees for PCP in order to further promote their development.

1.2. Forest Management and Forest Permit System in Indonesia

The majority of tropical forests, including those in Indonesia, is state forest that is managed under concession or permit system (Karsenty *et al.* 2008). Forest permit system has become the primary form of forest tenure and forest management (Walker and Smith 1993, Gray 2002, Burgess *et al.* 2012). Forest permit refers to a contract between a forest owner and another entity that permits the use and/or management of forest resources in a specified area at a definite time (Gray 2002). It may consist of utilization rights of forest resources (timber, non-timber, area and services) and management obligations/ responsibilities (for examples environmental protection and biodiversity conservation) embedded in that permit. The majority of forests in Indonesia is also state forest and managed under concession or permit system (Karsenty et al. 2008). Forest permit system has become the primary form of forest tenure and forest management around the world (Walker and Smith 1993, Gray 2002, Burgess *et al.* 2012).

Forests in Indonesia are broadly categorized into private forest and state forest. State forest, accounted for around 97.1% of total forests (RRI 2012), is classified into three major functional categories: protected forest, conservation forest, and production forest. Production forest has been the major portion of state forest, where generating various forest products is its main function (MoF 2008).

State forest management in Indonesia is broadly based on their main function categories, which are protected, conservation, and production forest. Protected forest has the natural function to manage hydrological functions, to prevent flooding and erosion, and to maintain soil fertility. Conservation forest is primarily functioned to conserve biodiversity and ecosystem. Production forest is designated to produce forest products (timber, non-timber, services, and area) to which their utilization is subject to permit or concession system; whereas, limited non-commercial human activities, however, are allowed in protected forest. In 2013, protected forest 22.6%, conservation forest accounts for nearly 20.6%, and production forest 56.8%, respectively (MoF 2013*a*).

Table 2. Types of forest permits, focusing on state forest (Note: * Central government approval is required to convert forest land uses into other non-forest uses; source: interpreted from Government Regulation No. 6/2007, Government Regulation No. 3/2008.)

Types of permits and activities	State forest					Private forest
	Production forests			Protected forest	Conservation forest	
	Permanent production forest		Convertible forest			
	Productive forest	Unproductive degraded forest				
Forest permits						
Commercial utilizations						
Timber extraction	*yes*	*yes*	-	-	-	-
Non-timber extraction	*yes*	*yes*	-	-	-	-
Area	*yes*	*yes*	-	*yes*	-	-
Forest services	*yes*	*yes*	-	*yes*	-	-
Non-commercial utilizations						
Timber extraction	*yes*	-	-	-	-	-
Non-timber extraction	*yes*	*yes*	-	*yes*	-	-
Others						
Research and development	-	-	-	-	*yes*	-
Education and training	-	-	-	-	*yes*	-
Religion and culture	-	-	-	-	*yes*	-
Non-forest uses						
Agricultural plantation	-	-	*yes**	-	-	-

Although tending to decrease, production forest has been the major portion of state forest, accounted for nearly 59.0% in 2011 (MoF several year publication), 57.1% in 2012, and 56.7% in 2013 of total state forest, respectively (MoF 2012, 2013*a*). It is further categorized into three secondary classes: permanent production forest, limited production forest, and convertible production forest. The two first classes are intended to be kept in state forest, whereas the last is allocated to be converted into non-forest uses. Permanent production forest is subject to relatively higher intensity of permitted logging (selective or clear cut), whereas timber utilization in limited production forest must be done selectively (MoF 2008).

Multifarious types of forest permits are issued (Table 2) within state forest. In production forest and protected forest, permits are issued for commercial and non-commercial uses, whereas research and development, educational and training or religious and cultural activity permits are issued in conservation forest.

Commercial timber extraction in production forest may involve two major permits. One is for productive (high tree cover) production forest, where permitted business entities may harvest timber selectively; the other is for unproductive production forest, where permitted business entities must first do planting and then harvest the timber when the planted trees are mature. Productive and unproductive areas are categorized by the following criteria presented in Table 3. Throughout the chapter, the first and the second type of permits are referred as logging permit (LP) and plantation conversion permits (PCP), respectively.

Table 3. Criteria of forest lands allocated for forest permits within production forest (Notes: * slope classification: A (0-8%); B (8-15%); C (15-25%); D (25-45%); E (>45%); source: Simplified from Annex III of SK.3803/Menhut-VI/BRPUK/2012.)

Criteria	Commercial timber extraction permits	
	Productive production forest for LP	Unproductive production forest for PCP
Macro		
Vegetation cover	Productive forest with forest cover >60%	Unproductive forest with forest cover <50% or non-forested
Slope*	A-B-C-D-E	A-B-C
Accessibility	Low-mid	Mid-high
Micro		
Timber potential (standing tree/ha)		No/small/not feasible
10-19cm	> 108	
20-49cm	> 39	
>50cm	> 15	
Non-timber potential	Yes	No

The government data, as of November 2012, presents that approximately 45.5% of production forest has been licensed for commercial timber extraction permits, leaving the rest to be un-managed or open-access areas. Among those permitted areas within production forest, LP and PCP have been the major permits, accounted for around 68.5% and 28.1% of total commercial timber extraction permits, respectively. Therefore, this analysis focuses primarily on commercial timber extraction permits, particularly LP and PCP. The other types of permits in Table 3 are assumed to have limited association to forest cover loss and thus are not included in this analysis.

1.3. Research Framework and Objectives

As explained in the previous sub-chapter, the production forest can be either the productive or the unproductive forest areas. Forest permits are issued to utilize forest resources and/or to manage forests. LP is designated in the productive forest areas, while PCP is designated in the unproductive forest areas. The main activities of forest permits is timber harvesting done by the holders or concessionaires. In recent decades, however, forest permit system has been criticized because of their damaging environmental impacts (Walker and Smith 1993; Barber and Schweithelm 2000; Gautam et al. 2000; Dennis et al. 2008; Amacher et al. 2012), namely biodiversity loss, forest degradation and deforestation (FAO 2001). Reducing deforestation when the majority of forest is managed under permit system (Gray 2002) has become increasingly challenging, both politically and economically (FAO 2001). However, there is no agreement on empirical evidence regarding the causality between forest permits and deforestation; their associations remain inconclusive. Therefore, the research is intended to estimate impacts of forest permits on deforestation.

Within forest permit system, global society has put a strong attention for unsustainable logging practices (Dudley et al. 1995; Sierra 2001; Gullison 2003; Damette and Delacote 2011). To counteract environmental issues surrounding timber harvesting, such SFM guidance or practices have been developed and promoted for decades (Gullison 2003; Dennis et al. 2008). To conceptualize, evaluate and implement SFM, criteria and indicators of SFM (or called C&I) have been developed, and globally emerged as a prominent instrument to promote SFM (Auld et al. 2008). Along with other deforestation reduction policies and strategies, Indonesia has adopted, developed and promoted SFM since 1993, in the forms of voluntary or market-driven schemes (by *Lembaga Ekolabel Indonesia* or LEI, the Forest Stewardship Council or FSC and the Indonesian Forestry Certification Cooperation or IFCC) and domestic government-established scheme. Although it has been more than two decades, the domestic SFM certification scheme in Indonesia has not been analysed yet. However, it is worthy to note that some studies have been done and working for the voluntary schemes (LEI or FSC). When SFM practices are well-implemented, it has a potential action to reduce the impact of logging activities under forest permits on deforestation. The second research topic in this dissertation aims at investigating this potential mitigation brought by the domestic SFM forest management certification scheme in Indonesia with regard to deforestation reduction.

As forest resources decline, forest land will be likely to be converted to other land uses. Forest conversion is also stimulated by other factors, especially higher rent values of other land uses. In Indonesia case, rapid agricultural expansion, especially oil palm (Casson 2000; MoF 2008; Hansen et al. 2009), has been cited to be one of the major causes of forest conversion. Oil palm plantation has been indicated to bringing significant pressure on forest (Barber and Schweithelm 2000; Margono et al. 2012) and has been considered to contribute a half of agricultural expansion (Wicke et al. 2011), as well as the major cause of deforestation in Indonesia at national level (Abood et al. 2014; Busch et al. 2015) and regional level, including Kalimantan (Carlson et al. 2012*a*, *b*; Gaveau et al. 2013) and Sumatera (Gaveau et al. 2009; Lee et al. 2014*b*). However, Wicke et al. (2011) indicates that at national level it does not appear to be the major cause of deforestation. Oil palm is a striking example of how agricultural expansion has threated forests (Sheil et al. 2009). Hence, one of the interests of this research is in the context of a strong competition circumstances between agricultural and forest land uses. While previous studies focus only on the aspect of area expansion of oil palm, this research incorporates productivity aspects to be investigated to what extent they affect forest cover loss.

In summary, the whole study is intended to understand to what extent do those three important factors (forest permits, SFM certification and agricultural technology improvement) affect deforestation in Indonesia (Figure 2). Specifically, three main objectives are derived, as followings: (1) to investigate whether forest permits cause deforestation; (2) to investigate whether SFM certification play a role to mitigate deforestation; and (3) to explore to what extent agricultural technology affect forest cover in Indonesia.

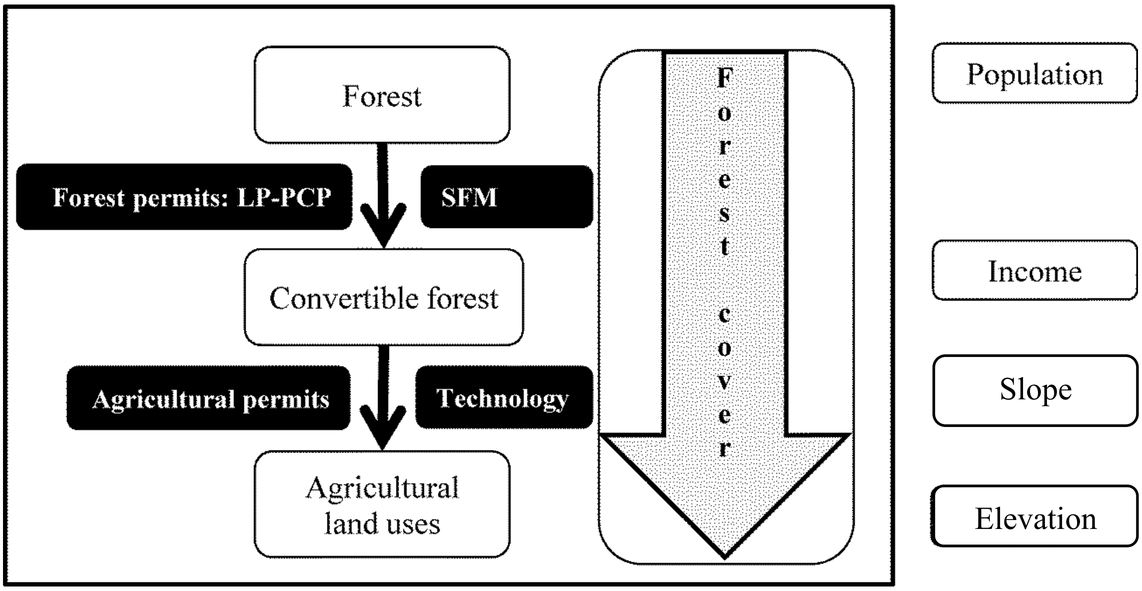


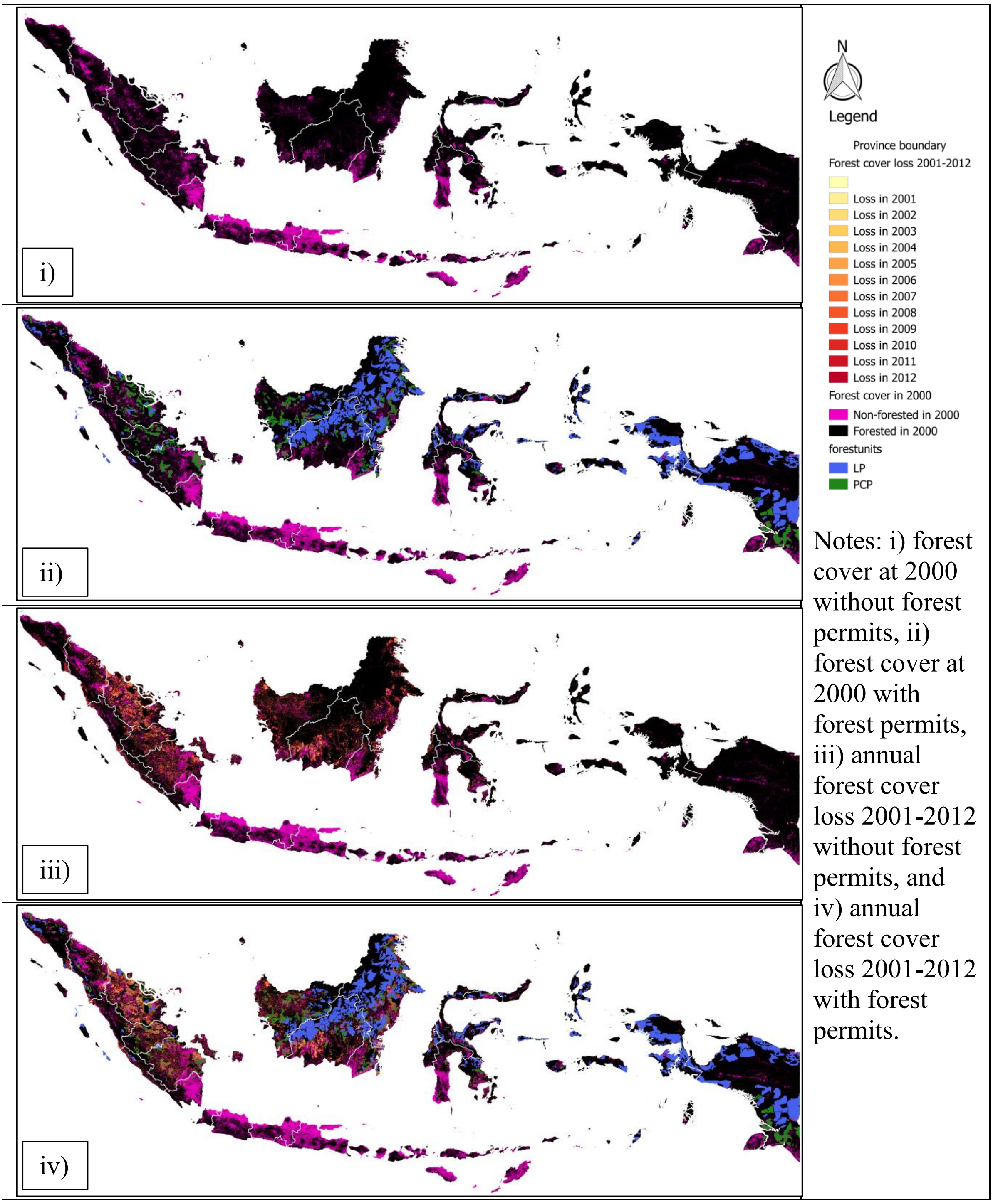
Figure 2. Research framework

Deforestation is a complex issue where various intertwined proximate and underlying factors are attributed (Kaimowitz and Angelsen 1998; Geist and Lambin 2001), including demographic, economic activities, political institutions, agricultural technology, attitudes and believes, has been taken into a strong consideration to play a critical role on the center stage of the development agenda, which is the competition for global agricultural land and forest resource (Stevenson et al. 2011). Those factors, including income, population and urbanization, are taken into account in the research framework, to have effects on forest cover change.

Analysis utilizes the first version of GFC or Hansen dataset 2000-2012 published in (Hansen et al. 2013*a*). The global dataset is presented into 10x10 degree tiles. All files contain unsigned 8-bit values. Files have a spatial resolution of 1 arc-second per pixel. At equator, per pixel covers approximately 30 meters. Information that is utilized in the analysis of this thesis is as followings:

i) tree cover at 2000, encoded as a percentage per output grid cell in the range 0-100 percent threshold and defined tree cover as canopy closure for all trees taller than 5 meters in height, and;
ii) forest cover loss event, as a disaggregation of total forest loss to annual time scales and encoded as 0 (no loss) or else in the range 1-12 representing loss detected primarily in the year 2001-2012, respectively.

The visualization of the dataset is presented in Figure . In the analysis, deforestation is measured by annual forest cover loss at current year. The first analysis investigating forest permits and deforestation and the third analysis investigating agricultural technology and deforestation have been done at provincial level. While, the second analysis investigating the domestic SFM certification and deforestation is at forest unit level.



Notes: i) forest cover at 2000 without forest permits, ii) forest cover at 2000 with forest permits, iii) annual forest cover loss 2001-2012 without forest permits, and iv) annual forest cover loss 2001-2012 with forest permits.

Figure 3. Forest cover at 2000 and annual forest cover loss 2001-2012 by province and by forest permits (Source: Hansen et al. (2013*a*)

1.4. Structure of Thesis

All those three main research objectives guide the structure of the thesis, as framed within in the research framework presented in Figure 4.

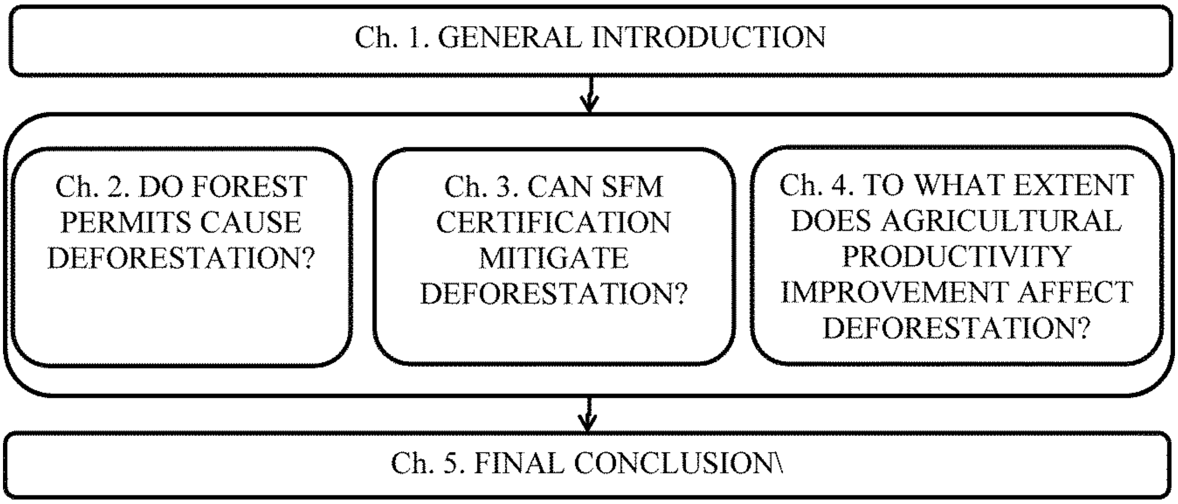


Figure 4. Structure of the thesis

As already presented, the first chapter provides some climate change and deforestation-related circumstances and progress at a global and regional level. It shows that deforestation has remained is the most critical environmental and climate change problem now and in the future. There is called for a stronger effort from the global community to halt deforestation. In more detail, Indonesia is one of the most deforested countries. Recent data show that its trend increases. It motivates this thesis to overlook and investigate several major factors in relation to deforestation in Indonesia, namely agricultural technology, forest permit policy and SFM certification.

The initial analysis begins, the second chapter, with looking at deforestation from outside forestry sector, which is agriculture sector. It has been cited and proved by empirical studies that agricultural expansion brings the most pressure on forest land uses in tropical countries, as well as in Indonesia. Unlike other previous studies which focus on agricultural expansion, analysis of this chapter is to test the hypothesis arguing that agricultural technology improvement can play a significant role to reduce deforestation.

From inside forestry sector, it has been recognized that most forest areas are owned by the government and managed under forest permits. Considering this important fact, therefore, the third chapter is to question their impacts on deforestation. Despites various types of forest permits, analysis are focused on logging and plantation conversion permits since their proportions are dominant.

To halt deforestation, SFM certification schemes have gained tremendous supports and hopes. They have been promoted and implemented widely, as well as in Indonesia. The voluntary SFM certification scheme has been the interest of many studies. The last analysis of this thesis, the fourth chapter, is intended to examine influences of another SFM scheme, which is the domestic SFM scheme, on deforestation.

For each analytical chapter, discussion covers some common sections, including background, review on theoretical and previous empirical studies, methods and data, results and discussions and concluding remarks. In the last chapter, thesis ends with final conclusions, recommendations and further studies.

CHAPTER II. DO FOREST PERMITS CAUSE DEFORESTATION?

2.1. Introduction and Objective

Reducing deforestation when the majority of forest is managed under permit system (Gray 2002) has become increasingly challenging, both politically and economically (FAO 2001). For example, there is no agreement on empirical evidence regarding the causality between forest permits and deforestation. In the case of Indonesia, certain scholars indicate that forest permits are the major cause of deforestation (Dauvergne 1993, Nawir *et al.* 2008, Molnar *et al.* 2011). Nonetheless, in several observational studies, those relationships are mixed. A study by Brockhaus et al. (2012) shows that LP in Sumatera and Kalimantan have had destructive impacts on forest cover, whereas studies by Gaveau et al. (2012) in Sumatera and by Gaveau et al. (2013) in Kalimantan suggest that LP has been a relatively effective mean of maintaining forest cover. A few scholars suggest that PCP has limited negative impacts (Meijaard and Sheil 2007), whereas some assert their positive contribution to deforestation (Kartodihardjo and Supriono 2000, Curran *et al.* 2004, Nawir *et al.* 2008, Obidzinski and Chaudhury 2009, Barr and Sayer 2012).

In summary, association between forest permits and forest cover loss or deforestation could be inconclusive. Results of some observational studies are valid for their specific cases and levels. While certain national forest policies need to be supported by certain general pictures at national level, a general association between forest permits and deforestation cannot be generalized from those micro/site-specific studies. This present analysis aims at fulfilling this gap by investigating general relationships between forest permits and forest cover loss at national level in Indonesia. In conclusion, results show that LP is not significantly associated to forest cover loss, while PCP considerably facilitates more forest cover loss.

2.2. Forest Permits and Deforestation

For decades, forest permits have been criticized by their negative environmental impacts, including forest degradation and deforestation. It is generally confirmed that selective logging under forest permits will directly diminish primary forest, transforming them into secondary degraded or logged-over forest. Utilization of timber within LP areas removes selected trees in primary forest (Fearnside 2005; Margono et al. 2012). Selective timber harvesting in primary forest can also unintentionally damage standing and small trees (Repetto and Gillis 1988; Verissimo et al. 1992; Iskandar et al. 2006). Intensifying or high-grading activities done by concessionaire have been found leading to forest degradation (Jepson et al. 2001; Curran 2004; Burgess et al. 2012). Development of logging roads to support concession activities facilitates forest fragmentation directly and indirectly (Skole and Tucker 1993; Achard et al. 2002; Fearnside 2005; Abdullah and Nakagoshi 2007; Fitzherbert et al. 2008; Arbainsyah et al. 2014; Margono et al. 2014). Some scholars find that logging roads have also widened canopy gaps (Sist et al. 2003; Fearnside 2005; Carlson et al. 2012*a*; Margono et al. 2012), leading to degrade forest.

On the other side, the association between forest permits and deforestation may not be simple, however. Conceptually, the direct impact of LP on deforestation will largely be determined by whether or not sustainable forest practices are implemented properly (Walker and Smith 1993; Damette and Delacote 2011). Unsustainable forest (Walker and

Smith 1993) and violation of such sustainable measurements (FWI/WRI/GFW 2002; Amacher et al. 2012) enable forest canopy declined drastically below the threshold of being considered as forests. Those mechanisms will turn into deforestation directly in permitted areas. Palmer (2000) reports that unsustainable timber extraction has not only been witnessed in the first round, but also during the second rotation. Some concessionaires have been found not undertaking replantation as regulated by the government (Nawir et al. 2008), from which natural regeneration process will unlikely take place. In general, due to little incentive (Palmer 2000; Merry et al. 2003) or lack of the government capability (MoF 2008; Burgess et al. 2012), the implementation of such sustainable forest practices are still poor or even violated. Only if such a sustainable practice is well-performed and not violated, forest permit system may not prompt to unplanned deforestation.

Illegal logging is another critical mechanism of unplanned deforestation under forest permit system (CIFOR 2004; Tacconi et al. 2004; MoF 2008; Burgess et al. 2012). Illegal logging may take place inside (Barr 2006) and outside permitted areas (Barr and Resosudarmo 2006; Smith et al. 2003; Curran et al. 2004; Fuller et al. 2004). Both concessionaire and/or outsider (local inhabitant/farmer) may be potential players of this activity. Overwhelming supply-demand gap of logs has driven concessionaires to involve in illegal logging (Holmes 2002); they may unsustainably extract timber in their areas by cutting more trees than are allowed (Amacher et al. 2012). Jepson et al. (2001) reports that, to compete with outsider illegal loggers, concessionaires have been found to illegally accelerate and intensify logging to harvest their timbers before felled by illegal loggers. They have faced little incentives to safeguard their areas (Palmer 2000) from illegal loggers (Abood et al. 2014).

Scholar also indicates that forest permit activities have been found to take place outside of permitted areas (Gaveau and Salim 2013). Protected forest is prone to illegal logging by concessionaires (Curran 2004) and farmers (Jepson et al. 2001). A recent study asserts that illegal logging by concessionaire can be induced by the dynamics of administrative jurisdictions or establishment of new local governments (Burgess et al. 2012). Moreover, regenerating areas has been indicated also being vulnerable of illegal re-logging in permitted areas (Palmer 2000; Barr 2001), which has further diminished timber availability during second rotation (Hoffman et al. 1999; Holmes 2002). Better infrastructure developed for the purposes of forest permits (Thiele 1994) has facilitated illegal access (Poffenbergen 1997; Barbier et al. 2010; Obidzinski et al. 2013) and illegal encroachment to remote primary forest by which land clearing has been commonly done (Fearnside 2005). In most tropical forest countries where regulations are poorly implemented and not well-enforced, illegal logging have remarkably contributed to deforestation (Burgess et al. 2012). In Indonesia case, this problem has been exaggerated by corruption (Palmer 2000; Amacher et al. 2012) as well as by weak and fragmented forest authorities (Smith et al. 2003).

Moreover, open access area is a serious issue, due to lack of government capability to manage forests. In Indonesia case, the government has so limited resources that only protected and conservation forests can be directly managed and supervised. Non-compliance cases have encouraged the government to revoke some forest concessions (Barber and Schweithelm 2000; Casson 2000; Kartodihardjo and Supriono 2000; Barr 2001, 2002). These revoked forest permit areas have become huge open access areas (Resosudarmo et al. 2012). In addition to withdrawn forest permit areas, around 54.5% of production forest have not been entitled any permits (MoF 2012). These open access areas are very vulnerable to illegal logging and illegal encroachment. Two important mechanisms are proposed to explain how open access may relate to deforestation (Barbier et al. 2010). The first is that rent-seeking behaviour, through which valuable forest resources (timber) are unsustainably extracted, will take place in open access areas. Secondly, very low or no opportunity costs of keeping those areas to be forests stimulates local inhabitants or farmers to convert them into higher market value non-forest uses. Open access forest is very prone to deforestation (von Amsberg 1994; Kaimowitz and Angelsen 1998; MoE 2010).

Conceptually, potential negative impact of PCP on deforestation is expected to result in a comparatively longer term, which is during harvesting planted tree period. However, since the government regulates that this permit should be legally established in unproductive production or degraded forest with low tree cover, its development is expected to significantly contribute to reforestation and forest rehabilitation programs (FWI/WRI/GFW 2002; Nawir et al. 2008; Resosudarmo et al. 2012). In fact, their immediate negative impacts on forest cover have been witnessed (Nawir et al. 2008), especially due to the fact that most PCP has been issued in relatively rich natural or high tree-covered forest (Barr 2002; Cossalter and Pye-Smith 2003; Obidzinski and Chaudhury 2009). Data and information about forest categories are lacking of clarity and accuracy (Brockhaus et al. 2012). Standing trees in degraded or logged-over forest with relatively high tree cover are removed (cleared cut) during the initial stage; land clearing is allowed during land preparation. In addition to little incentive for them to leave commercially valuable stems standing (Barr 2002), gaining double economic benefits from extracting timber cut during the forest clearing stage is their basic motivation in this business (Obidzinski et al. 2013); abandoning the land without doing replantation has been found in the field (Kartodihardjo and Supriono 2000). Illegal activities have been observed in PCP (FWI/WRI/GFW 2002).

Another crucial concern that forest permits might lead to deforestation immediately is through planned deforestation, conversion into non-forest uses. Tropical forests are very prone to agricultural expansion (Rudel and Roper 1997; Lopez 1998; Casson 2000). In Sumatera, for example, intensive forest clearing has resulted in the conversion of around 70% forested area through 2010 (Margono et al. 2012). Recent studies present that most remaining intact forest in Kalimantan (Gaveau et al. 2014) and in Papua (Brockhaus et al. 2012) will likely be converted under current designation. The government also tends to reclassify degraded or logged-over forest into convertible production forest after plantation conversion permit period (Cossalter and Pye-Smith 2003). This phase obviously lead to deforestation (Gaveau et al. 2012, 2013). Additionally, other indirect impacts include the induced effects of logging activities through forest fires (Thiele 1994). However, infrastructure provisions may either facilitate further pressure on forest land (Rudel and Roper 1997), as spatially explicitly occur in Papua (Margono et al. 2014), or improve forest management and monitoring (Mahapatra and Kant 2005). In production forest where LP and PCP are issued, forest degradation and deforestation may take place (Margono et al. 2012).

Lastly, it is about to briefly overview those intertwined processes between forest permits, forest degradation, and deforestation. Selective logging activities by LP directly degrade forest. There are also possible circumstances through which LP may limitedly induce deforestation, namely planned conversion and unsustainable logging. Planned conversion from production forest into large-scale non-forest economic activities will directly result in deforestation (Abood et al. 2014). As proven by (Margono et al. 2014) that most forest loss occurred in degraded forest (PCP areas), there are small portion where forest cover loss took place in natural forest (LP areas). Post-LP period when productive production forest falls under unproductive production forest, PCP takes place. In this phase, deforestation may be potentially caused by clearing the standing trees and, again, intended conversion. In general, logging precedes clearing (Margono et al. 2014); and, planned deforestation has a direct and obvious impact. Alongside those circumstances, illegal logging practices and negative effects of better infrastructure may play important roles during all phases.

2.3. Methods and Data

2.3.1. Conceptual Framework

This analysis has been framed in the proximate-underlying approach of deforestation (Geist and Lambin 2002). Proximate causes could relate to agricultural expansion, wood extraction, and infrastructure extension. These factors are usually used as other proxies of deforestation (Choumert et al. 2013). Underlying causes are classified into some factors: economic, demographic, technological, policy/institutional and cultural factors. In this analysis, forest permits are considered as one of the policy factors undertaken by the government in managing state forests. The government has a strong authority to issue or not, to revoke, to designate location, and to decide how much area will be permitted within production forest. Furthermore, economic, demographic, and technological factors represented by gross domestic regional product per capita (GRDP/capita), population and oil palm productivity, respectively, are other important factors affecting deforestation. It should be noted that cultural factors and other underlying variables are not incorporated in this analysis.

For economic factors, the immiserization theory postulates that rising economic levels (GRDP/capita) generate off-farm job opportunities that can prompt a shift away from reliance on forests (Rudel and Roper 1997). Conversely, the forest frontier theory suggests that better capital availability generated by economic development in forest regions enables loggers to expand and intensify their logging activities, which may or may not lead to greater deforestation (Rudel and Roper 1997). However, this study follows the findings of several studies showing that increasing GRDP/capita may increase deforestation, but at a certain level, it may reduce deforestation because of forest rehabilitation and reforestation programs. The existence of a U-shape Environmental Kuznets Curve (EKC) for deforestation is confirmed by some studies for Asian countries (Cropper and Griffiths 1994, Bhattarai and Hammig 2001, Culas 2007) and for tropical countries (Barbier and Burgess 1997). They argue that it is due to successful story of reforestation programs in certain tropical countries. Considering reforestation programs through PCP, this present analysis also hypothesizes that a U-shaped EKC for deforestation exists in Indonesia.

Demographic factors also have dual effects on deforestation. The Malthusian theory suggests that an increase in population increases pressure on natural resources (Palo 1994). However, the Boserup effect indicates that more population may reduce deforestation through better innovation, technology and institutions (Bilsborrow and Geores 1994). In the context of Asian countries, certain studies suggest that the population's effect on deforestation is insignificant (Cropper and Griffiths 1994, Koop and Tole 1999, Culas 2012). The notion of this analysis follows the Malthusian theory, hypothesizing that an increase in population increases deforestation. Population of Indonesian increased approximately 1.49% from 2000 to 2010 and is projected to grow 1.39% from 2010 to 2015 (BPS 2010).

Technology factors refer to technology in the agriculture sector regarded as one of the main pressures on the forest frontier. In Indonesia, oil palm development brings a significant pressure on forests. This study hypothesizes that better agricultural technology, represented by oil palm productivity, is negatively correlated to deforestation. Improving productivity enables oil palm plantations to produce more in the same amount of land (Mahapatra and Kant 2005), resulting in less demand of forest land to be converted and less pressure on forests. On the other side, higher oil palm productivity becomes a strong economic incentive of oil palm expansion. A more available capital generated by an increasing economic, likewise, will induce the development of oil palm plantation, bringing about more pressures on forests.

Since most forests are owned by the government, issuing and/or terminating forest permits is one of the important policies. LP is issued in the productive production forest. The holders are allowed to extract timber immediately, but selectively. On the other side, PCP that has been designed as one of the main programs of forest rehabilitation and reforestation should be established in unproductive production or degraded or logged-over forests. In this type of permit, conceptually, the holders can utilize those areas by planting trees first before harvesting timber. In practice, however, immediate clear cutting has been taking place during land preparation stage. Lastly, utilization production forest is subject to sustainable forest practices, expecting that the forest permits will not induce deforestation. Therefore, LP are hypothesized to positively and/or insignificantly associated with forest cover loss, while its negative correlation is expected for PCP. Some key attributes of LP and PCP are described in Table 4.

Table 4. Key attributes of logging permit and plantation conversion permit (Note: * criteria of forest lands allocated for logging and plantation conversion permits are given in Table 2; Source: Government Regulation No. 6/2007; Government Regulation No. 3/2008; the Ministry of Forestry Decree No. P.8/Menhut-II/2014.)

Type of forests	Logging permit	Plantation conversion permit
Original condition of forests*	Productive production forests.	Unproductive or degraded production forests.
Main purpose	Utilization of timber resources.	Rehabilitation of non-productive forests while utilizing timber products.
Major processes	Harvesting-selling-enriching-planting-growing.	Land preparation-nursery-planting-growing-harvesting-selling.
Application to	Central government.	Central government.
Maximum valid term	55 years and non-extendable.	60 years and extendable once for next 35 years.
Maximum area	50,000 ha (in Papua, 100,000 ha) and expandable.	50,000 ha (in Papua, 100,000 ha) and expandable only in some regions.
Limit per holder	Max 2 permits per company or 1 permit per holding company.	Max 2 permits per company or 1 permit per holding company
Property right for trees	Trees are not assets of permit holder.	Trees are assets of permit holder.
Eligible entities	Individual, cooperative, private, central/local state-owned company.	Individual, cooperative, private, central/local state-owned company.

2.3.2. Empirical Modelling

To estimate the impacts of LP and PCP on forest cover loss, a panel data is developed by using Forest Cover Change or Hansen dataset (Hansen et al. 2013*a*). The main interest of this study is the marginal effect of area of valid LP and PCP on forest cover loss. The econometric model is specified as follows:

$$DEF_{it} = \alpha_0 + \alpha_1 X_{it} + \alpha_2 LP_{it} + \alpha_3 PCP_{it} + u_t + \varepsilon_{it}$$

where DEF, LP, PCP, X, u, ε, i, and t denote deforestation, logging permit, plantation conversion permit, other potential explanatory variables, time or year effect, within-entity errors, province, and year, respectively.

Forest cover loss is used as the proxy of deforestation (DEF). Explanatory variables, including GRDP/capita, square of GRDP/capita, population and timber production are controlled in this model. These variables are very dynamic over time. To capture their circumstances, time effects that are measured as dummy variables of year are controlled in the model. Simultaneously, this step is also to accommodate the time lag effect of LP and PCP that cannot be directly reflected by our data. Furthermore, it takes into account roles of SFM, which is measured by FSC-certified area for both permits.

Since deforestation is a complex process, correlation between unobserved components and some explanatory variables is assumed to exist. To this end, the fixed-effect estimator is applied in this analysis (Damette and Delacote 2011). Heterogeneity issue is solved by running robust standard errors. Explanation of variables is presented in Table 5.

Table 5. Variables, data sources, and expected signs.

Variable	Explanation	Unit of measurement	Source of data	Expected sign
Dependent variable				
DEF	Area of forest cover loss at 30% threshold of canopy cover.	ha	(Hansen et al. 2013*b*)	-
Independent variables				
LP	Areaof logging permits.	ha	Ministry of Forestry	Insignificant/ Positive
PCP	Area of plantation conversion permits.	ha	Ministry of Forestry	Negative
GRDPcap	Provincial GRDP per capita.	Rp 000/capita (in 2000 constant)	BPS-Statistics Indonesia	Negative
sqGRDPcap	Square of GRDPcap.	-	-	Positive
POP	Number of population.	Number	BPS-Statistics Indonesia	Positive
FSC_LP	Area of FSC-certified area for LP.	ha	Ministry of Forestry	Negative
FSC_PCP	Area of FSC-certified area for PCP.	ha	Ministry of Forestry	Negative
LOG	Volume of timber production.	m^3	Ministry of Forestry	Positive

2.3.3. Data

The data of this study are provincial data covering all provinces in Indonesia. The data of deforestation (forest cover loss), the dependent variable, are based on Hansen dataset (Hansen et al. 2013*a*) and accessed from Global Forest Watch website (Hansen et al. 2013*b*). In this dataset, forests refer to tree cover, where trees are defined as all vegetation taller than 5 meters in height and canopy cover at least 30% at the Landsat 30 x 30 meters pixel scale. By this definition, commercial forestry plantations, as well as primary and secondary forests, are accounted as forests. To be in line with how the government defines forests (MoF 2008), the threshold of 30% canopy cover was chosen. Threshold of 10% canopy cover was utilized to check the robustness of estimation results (Table Annex 1). Deforestation is defined as forest cover loss, the disturbance or complete removal of tree cover canopy at the current year for each province. Positive value of forest cover loss represents the magnitude of deforestation area.

Since the government has not designated any LP and PCP in the provinces within Java and Bali islands, this analysis employs 26 out of 33 provinces, excluding the provinces in Java and Bali. This study takes into account the dynamics of decentralization in which new provinces were established (Banten from West Java in 2000, Kepulauan Bangka Belitung from Sumatera Selatan in 2000, Gorontalo from Sulawesi Utara in 2000, Papua Barat from Papua in 2001, Kepulauan Riau from Riau in 2002, and Sulawesi Barat from Sulawesi Selatan in 2004). In those cases, the data of the explanatory variables are available one year after their establishment years. Therefore, the balanced panel data for this analysis is in the period of 2005-2012. Data is summarized in Table 6 and Table Annex 2 for a more detail.

Table 6. Descriptive statistics of main variables, 2005-2012

Variable	Obs.	Mean	St. Dev.	Minimum	Maximum
DEF	208	58 050.97	80 577.85	1 146	353 590
LP	208	1 003 365.00	1 742 085.00	0	6 773 357
PCP	208	339 940.40	507 413.80	0	1 966 186
GRDPcap	208	8 256.38	6 651.05	2 166	32 689
POP	208	36 39707.00	2 737 832.00	643 012	1.33e+07
FSC_LP	208	14 517.23	62 570.30	0	462 710
FSC_PCP	208	10 106.99	46 423.42	0	260 829
LOG	138	1 066 188.00	2 282 799.00	0	1.80e+07

2.4. Results and Discussions

2.4.1. Descriptive Statistics

Forest Cover Change or Hansen dataset shows that Indonesia has experienced an increasing trend of forest cover loss during 2001-2012. Forest cover has been reduced from around 0.75 million in 2001 ha to 2.03 million ha in 2012 (Figure 1.), or on average nearly 1.30 million ha/year during this period. In fact, after the implementation of the forest moratorium policy since 2011 forest cover loss has drastically moved upward in the rate nearly 34.1% from 2011 to 2012. This fact raises an interesting question about the actual effect of this policy to reduce deforestation (Murdiyarso et al. 2011; Laurance et al. 2012; Margono et al. 2014). In more detail at province level during 2005-2012 (Figure Annex 1), Riau, Kalimantan Tengah, Kalimantan Barat, Kalimantan Timur, and Sumatera Selatan have experienced relatively high forest cover loss. Increasing trend of forest cover loss has been found in Kalimantan Barat, Kalimantan Timur, Riau, Papua, and Sumatera Selatan.

LP has decreased in terms of both area and number of units, while PCP has increased over time (Figure 5) during the period of 2001-2012. The decreasing trend of LP has continuously been witnessed in longer spare of time since 1989. Several circumstances, including the depletion of natural forest, the increasing of social conflicts, forest fires, and emerging environmental campaigns (Singer 2008), are proposed to explain this circumstance. Recent government policy directions (the forest moratorium policy and the forest tariff policy) move along those trends. At province level, large areas of LP have been taking place in Kalimantan Timur, Kalimantan Tengah, Papua, and Papua Barat during the period 2005-2012 (Figure Annex 2); whereas large areas of PCP have been found in Kalimantan Barat, Kalimantan Timur, Riau, and Sumatera Selatan (Figure Annex 3).

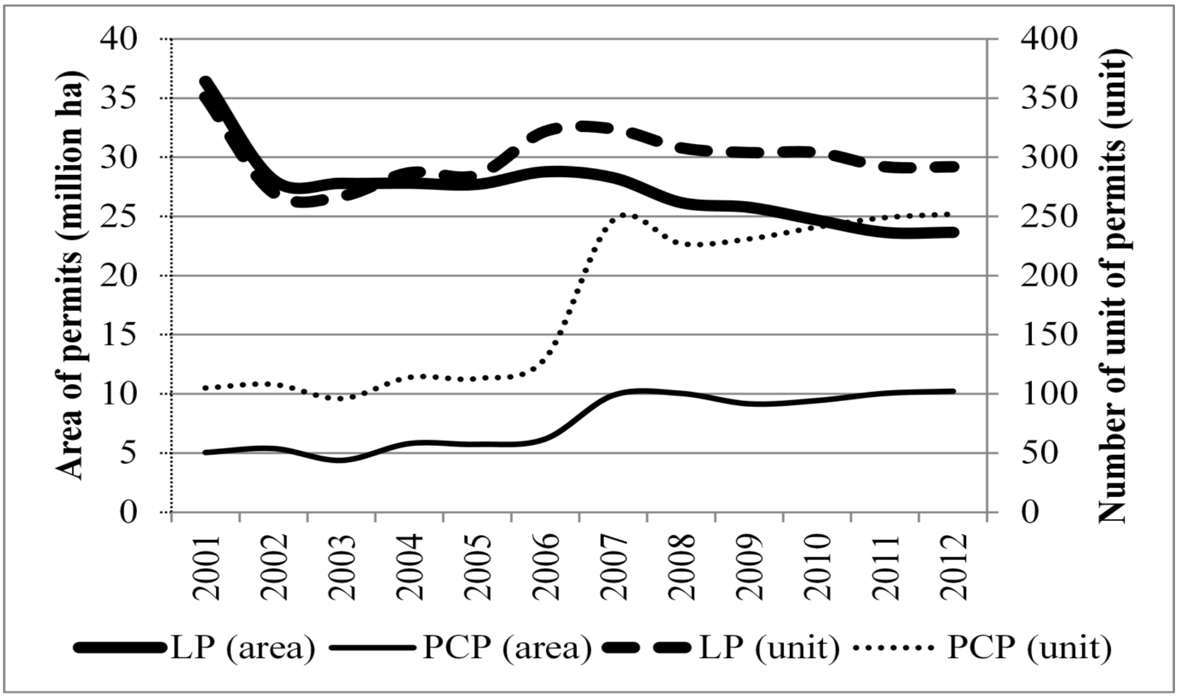


Figure 5. Valid logging and plantation conversion permits, in million ha of the area and in number of units, 2001-2012 (Source: MoF 2014b).

2.4.2. Econometric Results

Table 7 reports estimation results of this study. When timber production is not controlled in the model (Reduced form model), LP has a positive and significant correlation to forest cover loss. However, its impact becomes insignificant when timber production is considered in the model (Full model). On the other side, results on PCP bring a consistent sign in which this type of permit is positively associated with forest cover loss. This analysis estimates an increasing 1 ha PCP is likely to increase loss of forest cover by nearly 0.073 ha.

In addition to LP and PCP, the volume of timber production has played a significant role to forest cover loss, in which an increasing 1 m^3 of timber production is estimated to reduce around 0.005 ha forest cover (Full model). We further checked whether forest permits contribute to timber production, resulting in insignificant signs for both permits (see Table Annex 3). Another interesting finding is that magnitude of SFM implementation (represented by certified area) has been insignificantly associated to forest cover loss.

Table 7. Estimation results: impacts of logging and plantation conversion permits on forest cover loss (threshold 30% of canopy cover) (Note: robust standard errors are in parentheses; significance at 1%, 5%, and 10% are denoted by ***, ** and *, respectively.)

Variables	Basic model	Reduced form model	Full model
GRDP/cap	19.9953	11.5636	21.9947
	(5.2480)***	(5.2700)**	(7.4160)***
Square of GRDP/cap	-0.000862	-0.000517	-0.000967
	(0.0002)***	(0.000195)**	(0.0003)***
Number of population	0.0307	0.0560	0.0337
	(0.0272)	(0.0180)***	(0.0271)
Area of LP	0.00553	0.00759	0.00567
	(0.0717)	(0.00315)**	(0.0034)
Area of PCP	0.0717	0.0695	0.0733
	(0.0271)**	(0.0231)***	(0.0272)**
Timber production	0.00481		0.00482
	(0.0021)**		(0.00217)**
LP SFM-certified area		0.0169	0.0481
		(0.0873)	(0.109)
PCP SFM-certified area		-0.0377	-0.0347
		(0.0506)	(0.0469)
Year effect	Yes	Yes	Yes
Constant	-168,611	-212,114	-183,936
	(102.5090)	(68.8800)***	(108.9610)
Number of observations	200	286	200
Number of provinces	26	26	26

The signs of control variables are consistent with expectations. Interestingly, a positive significant sign of GRDP/capita and a negative significant sign of its square confirm that an inverted U-shaped EKC for deforestation exists in Indonesia. A U-shaped EKC for deforestation may be held in Asian and/or the tropical forest country levels (Cropper and Griffiths 1994, Barbier and Burgess 1997, Bhattarai and Hammig 2001, Culas 2007), but not in Indonesia case. With regard to demographic factors, the parameter of the number of population results in a positive significant sign when timber production is not controlled. At the last, however, this variable ends up with an insignificant effect on forest cover loss (Full model). This result supports some regional studies for Asian country case (Cropper and Griffiths 1994, Koop and Tole 1999, Culas 2012, Wheeler *et al.* 2013).

Although permit system has been widely implemented as a dominant policy in managing the vast majority of global forests, to the best of our knowledge, forest permits have rarely been integrated into such quantitative studies. On a global level, however, Damette and Delacote (2011) use timber harvesting (volume and value) in explaining deforestation rates. This cross-national panel data from 1972-1994 indicates that timber harvesting is positively associated with deforestation.

At national level in Indonesia case, few quantitative studies have focused on the association between forest permits and deforestation, with the exception of studies by Busch et al. (2011) and Wheeler et al. (2013). Both studies, however, do not focus on estimating and discussing impacts of forest permits on deforestation. The main interest of the former study is to analyse relationship between carbon payments and deforestation, while the primary purpose of the latter work is how relative prices of agriculture and forest affect the probability of forest clearing at micro/site level. Nevertheless, it is worth mentioning that they controlled LP and PCP in their econometric models, resulting in a negative sign for LP and a positive sign for PCP. None of them discusses why those signs arrived.

At regional (island) level, two other notable quantitative studies are done by Gaveau et al. (2012) for Sumatera case and Gaveau et al. (2013) for Kalimantan case. Their propensity score matching and linear regression models show an insignificant difference of the deforestation occurring in LP and protected forest areas. They, in conclusion, highlight similar ability of LP (referring to natural forest timber concession on their papers) as protected forest to maintain forest cover in Sumatera and Kalimantan cases, subject to prevention from reclassification and conversion. Unlike those aforementioned quantitative studies, this current analysis is able to quantify general impacts of forest permits on forest cover loss in Indonesia. Table 8 presents the position of our study among other quantitative studies.

Results of LP in this study, finding an insignificant association between LP and forest cover loss, are different with the results of Busch et al. (2012) and Wheeler et al. (2013). Different unit of analysis may lead to different results and interpretation. The unit of forest permits in both first studies is the percentage of forest permit areas in total land area, while this current analysis takes the magnitude of forest permit areas as the measurements. It may also due to the differences in the dependent variables and econometric models. The former study pays less attention to macro-economic-demographic variables in the association with deforestation rate, while the latter incorporates fewer control variables to be correlated to the forest clearing index. Finding an insignificant correlation between LP and forest cover loss, our results are more or less concurrent with those of two studies in Sumatera and Kalimantan cases (Gaveau et al. 2012, 2013). They have a different focus, as well as a particular merit, in which they estimate association of forest permits in comparison to that in other forest uses (unprotected, protected, and managed protected forest, and oil palm plantation). Their results, indeed, apply only for Sumatera and Kalimantan cases. Our analysis does not utilize other forest uses as the benchmark for comparison. Unlike aforementioned studies, this current analysis took into account environmental management factor (FSC-certified area) as suggested by Damette and Delacote (2011). This current study is able to confirm a general association between LP and forest cover loss at national level in Indonesia, showing that they are not significantly associated each other. As reviewed in previous section, a positive significant correlation between LP and deforestation reported by some micro/site studies are valid for their specific cases, and cannot be generalized into national level in Indonesia.

Conversely, PCP has moved toward an unexpected direction, leading to forest cover loss. The growing demand of log for forest-based products has prompted the government to establish PCP since 1986 (Obidzinski and Chaudhury 2009; Brockhaus et al. 2012). Since 1990 when forest land has started to be seriously degraded, the government has further promoted PCP, expecting that the development of this monoculture fast-growing forest can considerably contribute to reforestation and rehabilitation programs (FWI/WRI/GFW 2002; Nawir et al. 2008; Resosudarmo et al. 2012). This analysis, unexpectedly, results in a positive significant effect of PCP on forest cover loss.

Table 8. Position of the present analysis (Note: * Data is stratified into 5 classes of forest cover: no forest cover, low forest cover, low-medium forest cover, medium-high forest cover, and high forest cover; ** Monthly change of forest cover in the number of 1 km^2 that have experienced clearing with probability more than 50%.)

Aspect	Busch et al. (2012)	Wheeler et al. (2013)	Gaveau et al. (2012) and Gaveau et al. (2013)	This Present Analysis
Measurement of deforestation	Deforestation rate*) for 5 years.	Forest clearing index**).	Deforestation rate as of 1990 and tree cover loss.	Forest cover loss.
Type of permits	Logging and plantation conversion permits (% of land area).	Designated zone for logging and plantation conversion permits as of 2005 (% of land area).	Logging permits, oil palm permits, and protected forests (area).	Logging and plantation conversion permits (area).
Unit of analysis	Grid cells, average trend.	Grid cells converged into district level, monthly.	Grid cells, average.	Grid cells converged into provincial level, annual.
Coverage (spatial and temporal)	All provinces and districts; 2000-2005.	All provinces and districts excluding provinces in Java, Bali and Nusa Tenggara, 2006-2010.	Sumatera, 1990-2000 and Kalimantan, 2000-2010.	All provinces excluding provinces in Java and Bali; 2000-2012.
Empirical method	Cross-section negative binomial regression with Poisson quasi-maximum likelihood and robust standard errors.	Random effects and spatial autocorrelation.	Propensity score matching and linear regression.	Fixed effects with year effect and robust standard errors.
Economics-demographic factors	-	Population density and poverty rate in 2000.	-	GRDP/capita, population, population density, population growth, oil palm productivity, and timber production.
Environmental factor	-	-	-	Forest certification.
Source of data	OSIRIS v1.5 database (satellite data).	FORMA database (satellite data).		Forest Cover Change or Hansen dataset (satellite data).

The fact that areas of reforestation program have been continuously much less than the scale of deforestation over period supports the results (Figure 6). Furthermore, the government data (MoF 2012) also show that permitted areas for PCP (11.83 million ha in 2011 and 3.80 million ha in 2012) have been much less than areas requested by companies

(0.76 million ha in 2011 and 0.82 million ha in 2012). Lastly, inability of PCP to deal with deforestation is in line with data presented in Figure II-2 affirming that areas covered by PCP have continuously been smaller than those covered by LP. PCP is not able to cover whole degraded/logged-over forests; PCP cannot offset deforestation (Nawir *et al.* 2008). Instead, increasing its area will facilitate more forest cover loss. These findings support results of some observational studies and reports (Kartodihardjo and Supriono 2000; Cossalter and Pye-Smith 2003; Nawir et al. 2008; Obidzinski and Chaudhury 2009; Brockhaus et al. 2012).

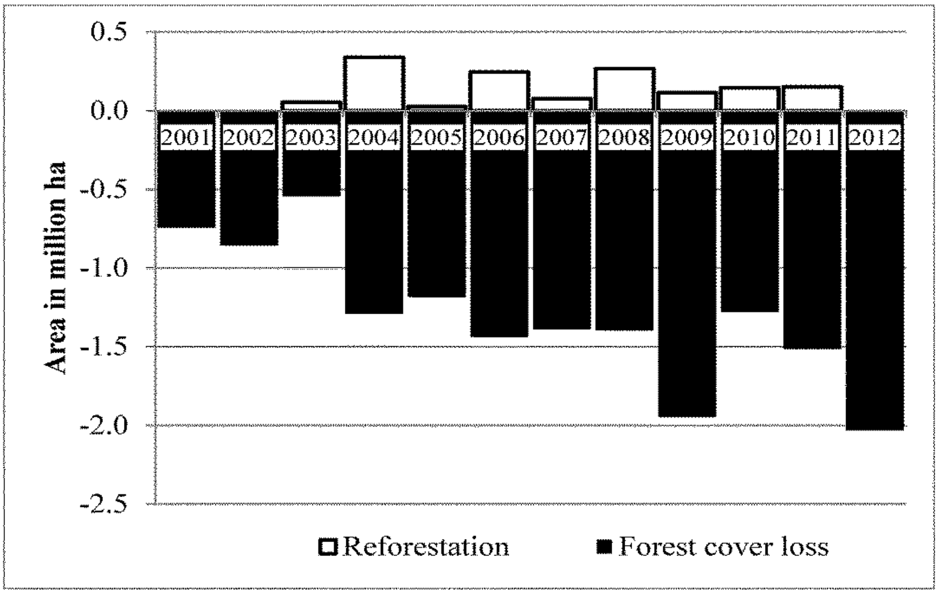


Figure 6. Area of reforestation program and forest cover loss (threshold 30% of canopy cover) in million ha, 2001-2012 (Note: data of reforestation programs in 2001, 2002, and 2012 is not available; Source: analysed from MoF 2014)

2.5. Conclusions and Policy Implications

This analysis quantitatively estimates impacts of forest permits (areas of valid LP and PCP) on forest cover loss in Indonesia. Based on the results, this analysis argues that insignificant correlation between LP and forest cover loss and significant positive impact of PCP on forest cover loss is the general association between forest permits and forest cover loss at national level in Indonesia. These main findings partly support result of a spatially explicit study finding that logging precedes clearing (Margono et al. 2014). The development of PCP significantly diminishes forest cover at the expense of the primary forest (Kartodihardjo and Supriono 2000). In addition to these findings, increasing areas of forest certification cannot significantly mitigate forest cover loss, while timber production has a considerable role in the diminishing forest cover. It calls further researches to investigate the current performance of SFM practices and invisible role of illegal logging, including legalizing illegal logging activities. This analysis, additionally, clarifies that a U-shaped EKC for deforestation in Indonesia does not exist, but an inverted U-shaped.

Reflecting these main results, for the forest moratorium policy and the forest tariff policy, it is suggested that discouraging and/or limiting LP in general may not effectively contribute to the attempts in reducing deforestation. Rather, considering the fact that open access areas are enormously large, potential ability of LP to maintain forest cover (Meijaard and Sheil 2007; Fisher et al. 2011; Gaveau et al. 2012, 2013) could be further examined as a possible policy to reduce deforestation. On the other hand, promoting PCP has contradicted to the efforts in reducing deforestation. Based on these results, assuming other factors are held constant, discouraging and/or suspending new PCP is another alternative policy that could be further examined in reducing deforestation for short run. Comparing to the criteria of forest and/or deforestation in which the threshold of forest cover is up to 30%, it is argued that the current criteria of forest cover for the unproductive forest is too high. Consequently, to further limit PCP area through directing PCP toward degraded forest with relatively low tree cover, the government should immediately revise the criteria of the unproductive production forest to have tree cover up to 30% in order to be in line with how forest is defined by the government. The government needs to pay attention to essentially revitalize PCP in order to redirect its current path toward reforestation and forest rehabilitation programs; such a comprehensive evaluation of PCP is an important initial step.

In longer term, instead of revoking either non-compliance permits or PCP that is found by this analysis to have a positive contribution to forest cover loss, the government should urgently emphasize on real actions to improve the existing on-the-ground environmental performance of forest permits (Gray 2002, McAllister *et al.* 2007). Improving clarity and accuracy of forest categories allocated for forest permits (Brockhaus et al. 2012), preventing conversion of forest permit areas into non-forest uses, and alleviating illegal logging are among the alternative actions for consideration in forest permit-related policies. Finally, proposed policies have to be promptly enforced into real actions and be framed in the context of evidence-based forest management and forest governance (Jepson et al. 2001; Blair et al. 2007).

Appendix

Table Annex 1. Estimation results: impacts of logging and plantation conversion permits on forest cover loss (threshold 10% of canopy cover) (Note: robust standard errors are in parentheses; significance at 1%, 5%, and 10% are denoted by ***, ** and *, respectively.)

Variables	Basic model	Reduced form model	Full model
GRDP/cap	20.0165	11.5782	22.0316
	(5.2610)***	(5.2820)**	(7.4360)***
Square of GRDP/cap	-0.000863	-0.000518	-0.000969
	(0.0002)***	(0.0002)**	(0.0003)***
Number of population	0.0307	0.0560	0.0337
	(0.0273)	(0.0180)***	(0.0271)
Area of LP	0.00555	0.00762	0.00569
	(0.0033)	(0.0032)**	(0.0034)
Area of PCP	0.0719	0.0697	0.0734
	(0.0271)**	(0.0232)***	(0.0273)**
Timber production	0.00484		0.00484
	(0.0021)**		(0.0022)**
LP SFM-certified area		0.0173	0.0484
		(0.0878)	(0.1090)
PCP SFM-certified area		-0.0379	-0.0350
		(0.0508)	(0.0472)
Year effect	Yes	Yes	Yes
Constant	-168,601	-212,252	-184,047
	(102.6970)	(69.0250)***	(109.2010)
Number of observation	200	286	200
Number of province	26	26	26

Table Annex 2. Descriptive statistics of panel data, 2005-2012

Variable		Mean	Standard deviation	Minimum	Maximum	Observations
DEF	overall	58 050.97	80 577.85	1 146.00	353 590.00	N = 208
	between		76 469.22	2 174.50	266 661.80	n = 26
	within		29 034.32	-31 539.00	210 054.00	T = 8
LP	overall	1 003 365.00	1 742 085.00	0.00	6 773 357.00	N = 208
	between		1 765 816.00	0.00	6 221 368.00	n = 26
	within		148 981.40	269 446.60	1 612 888.00	T = 8
PCP	overall	339 940.40	507 413.80	0.00	1 966 186.00	N = 208
	between		490 010.30	0.00	1 457 750.00	n = 26
	within		159 619.20	-457 671.0	1 108 101.0	T = 8
GRDPcap	overall	8 256.38	6 651.05	2 166.00	32 689.0	N = 208
	between		6 701.10	2 573.18	31 689.11	n = 26
	within		922.10	5 077.66	14 248.56	T = 8
LOG	overall	3 639 707.00	2 737 832.00	643 012.00	1.33E+07	N = 208
	between		2 779 276.00	725 706.90	1.28E+07	n = 26
	within		180 435.10	3 103 806.00	4 230 581.00	T = 8
FSC_LP	overall	14 517.23	62 570.30	0.00	462 710.00	N = 208
	between		52 327.58	0.00	241 339.80	n = 26
	within		35 629.51	-110 222.00	352 488.50	T = 8

Variable		Mean	Standard deviation	Minimum	Maximum	Observations
FSC_PCP	overall	10106.99	46 423.42	0.00	260 829.00	N = 208
	between		36 800.32	0.00	163 018.10	n = 26
	within		29 097.54	-152 911.00	107 917.90	T = 8
POL	overall	1 066 188.00	2 282 799.00	0.00	1.80E+07	N = 138
	between		1 844 244.00	4 214.93	8 548 080.00	n = 26
	within		1 248 778.00	-7 445 841.00	1.06E+07	T-bar = 5.30

Table Annex 3. Estimation results: logging and plantation conversion permits on timber production (Note: robust standard errors are in parentheses; significance at 1%, 5%, and 10% are denoted by ***, ** and *, respectively.)

Variables	Timber production
Area of LP	0.247 (0.210)
Area of PCP	0.215 (0.700)
LP SFM-certified area	1.402 (1.836)
PCP SFM-certified area	1.181 (6.478)
Number of population	3.891 (2.584)
Year effect	Yes
Constant	-1.363e+07 (9.580e+07)
Number of observation	207
Number of province	26

Figure Annex 1. Forest cover loss by province, threshold 30% canopy cover, in ha, 2005-2012 Source: Hansen et al. (2013b).

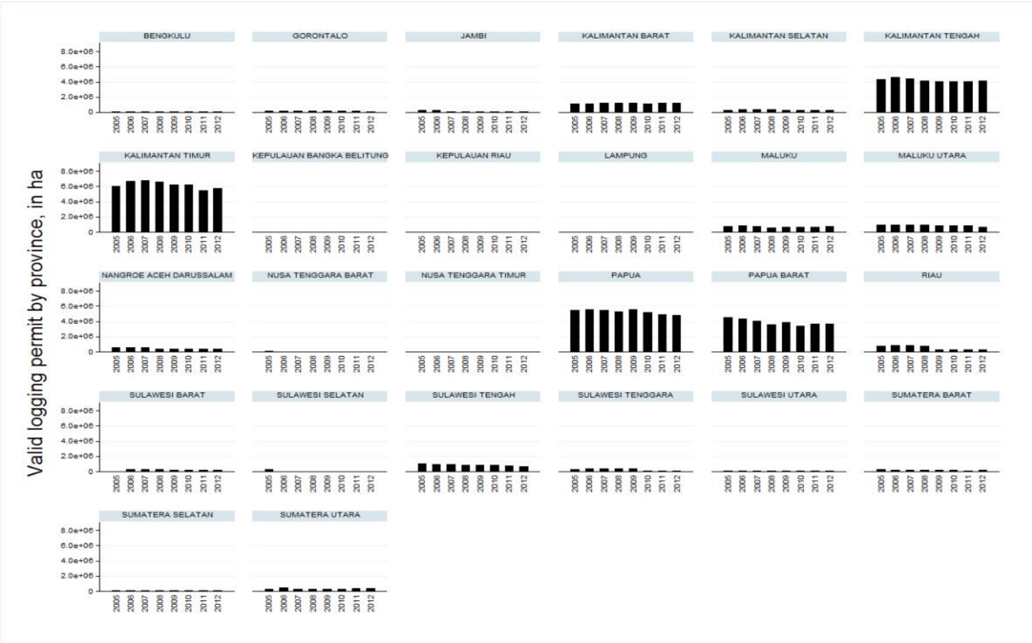


Figure Annex 2. Area of existing valid logging permit (LP) by province, in ha, 2005-2012 (Source: MoF 2014).

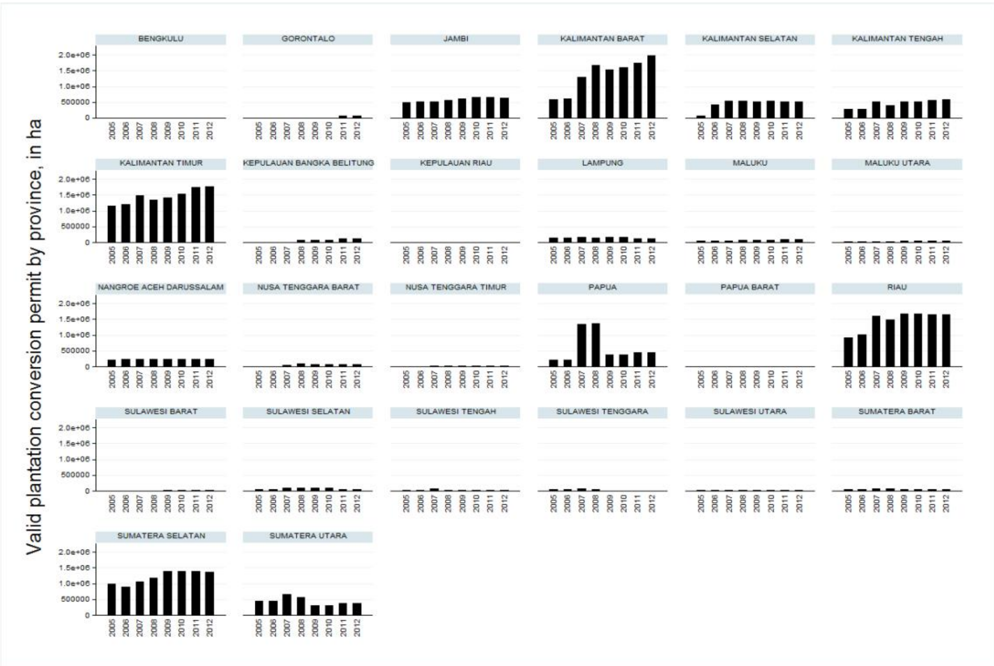


Figure Annex 3. Area of existing valid plantation conversion permit (PCP) by province, in ha, 2005-2012 (Source: MoF 2014).

CHAPTER III. CAN SUSTAINABLE FOREST MANAGEMENT MITIGATE DEFORESTATION?

3.1. Background and Objective

Forest permits has been criticized for their deleterious impacts on environment, including unsustainable logging practices (Dudley et al. 1995; Sierra 2001; Gullison 2003; Damette and Delacote 2011) that potentially affects forest. This circumstance and the emerge of global concern on deforestation and biodiversity loss since 1980s have led to a global need of SFM (Stringer 2006). Derived from the Forest Principles agreed during the Earth Summit 1992 (Stringer 2006) and then further defined in the Helsinki Resolution 1993 (Mayer 2000), SFM has been increasingly promoted and implemented widely. Nearly 150 countries have involved, covering approximately 97.5% of the global world forests (Wijewardana 2008). It is argued that its implementation is able to integrate logging activities in a sustainable manner (van Kuijk et al. 2009) and brings a preferable practice compared to a complete forest protection (Putz et al. 2000). In the long term perspective, the implementation of SFM may prevent negative effects of logging while maintaining their benefits (Clark and Kozar 2011). In this global climate change era, the enhancement and the expansion of SFM practices is expected to play more significant roles as one of the main mitigation actions to halt deforestation. However, this key message of SFM (Cashore et al. 2004; Marx and Cuypers 2010; Chávez and Cossío 2013) has not been widely scrutinized.

As one of the largest forest tropical countries experiencing relatively rapid rate and large area of deforestation, Indonesia has been the subject of international scrutiny, as well as in the context of SFM (Bartley 2010). In the 1990s, Indonesia had a big international pressure, when some global environmental organizations called European countries and the US to boycott Indonesian wood products (Stringer 2006). Simultaneously, in 1990, Indonesia also experienced an early international experiment of SFM certification, when SmartWood Certification Program certified Perum Perhutani (Muhtaman and Prasetyo 2006). Considering those substantial global attentions, the development of SFM in Indonesia is expected to be significantly noticeable (Bartley 2010).

Indonesia has adopted, developed and promoted SFM since 1993 through the establishment of the Ministry of Forestry Decree No. 252/Kpts-II/1993 (Muhtaman and Prasetyo 2006). Since then, SFM has been implemented either as the domestic SFM certification scheme and/or the voluntary one (Table 9). As the domestic scheme, any forest management under forest permit or concession system in production forest is legally obliged to be certified by this domestic SFM certification scheme established by the government (MoF 2014*c*). Furthermore, there have also been three voluntary (non-state market-driven) schemes in Indonesia, developed by *Lembaga Ekolabel Indonesia* (LEI – the Indonesian Ecolabelling Institute) since 1993, a Joint Certification Protocol (JCP) between LEI and the Forest Stewardship Council (FSC) since 1999, and the Indonesian Forestry Certification Cooperation (IFCC) since 2012 in which their standards have just been endorsed by the Programme for the Endorsement of Forest Certification (PEFC) since 2014.

The voluntary SFM certification schemes has been studied and evaluated by several studies at global and other countries' cases (Gullison 2003; Cashore et al. 2004; Gan 2005; Auld et al. 2008; Hughell and Butterfield 2008; Damette and Delacote 2011; Bartley 2014).

At national level, some studies have also been conducted. Some scholars have come up with an optimistic hope (Takahashi 2008; Arbainsyah et al. 2014), while others have not (Muhtaman and Prasetyo 2006; Bartley 2010; McCarthy 2012; Obidzinski et al. 2013; Griscom et al. 2014). The progress of voluntary SFM scheme is far from expectation. For example, in 2009, LEI-certified and FSC-certified forest areas were only approximately 1. 50 million ha (or nearly 1.2% of total forest) and 1.09 million ha (or nearly 0.9% of total forest), respectively (Bartley 2010). On the other side, although it has been developed and promoted for more than two decades, the domestic SFM certification scheme covering much larger areas has not been an interest of any study. Hence, this analysis is intended to fulfil this gap by exploring the extent of the domestic SFM certification towards forest mitigation in Indonesia.

Table 9. Current SFM certification schemes in Indonesia

SFM certification scheme	Main characteristic	Domestic endorsement	International endorsement
Domestic	Government-led.	The government.	-
Voluntary	Non-state market-driven.	LEI and IFCC.	FSC.

3.2. SFM Certification and Deforestation

3.2.1. Its Potential Contributions to Mitigate Deforestation

SFM is rooted from the Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests, known as the Forest Principles, and agreed in the United Nations Conference on Environment and Development (UNCED) or the Earth Summit 1992 (Stringer 2006). Then, in 1993, the Helsinki Resolution further defined it as “the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems”. This definition is then adopted by FAO (Mayer 2000).

As a tool for monitoring, assessing and reporting changes and trends in forest conditions and management systems at the national and forest management unit levels, SFM is operationally codified and translated into C&I to be functioned as the conceptualization and evaluation tool of SFM (Auld et al. 2008). The development of C&I has been pioneered by the International Tropical Timber Organization (ITTO) since 1992. C&I provide a means of assessing forest management progress towards SFM (ITTO 2005).

Since logging is not always correlated with deforestation, the relation between logging/timber harvesting, SFM and deforestation need to be clearly comprehended. Damette and Delacote (2011) argues that if harvested natural forest is conducted selectively, replanted, left regrown and not converted to non-forest land uses, logging activities will not lead to deforestation. In this context, SFM could provide room to improve forest management from conventional unsustainable management to certified sustainable one (Karsenty et al. 2008), or even to more efficient production system (Nebel et al. 2005). By implementing SFM that prescribes sustainable practices, poorer managed forest manager can improve their current management practices towards higher standards and more sustainable level (Damette and Delacote 2011). SFM may positively offer behavioural change of producers (Tikina and Innes 2008) that, in turn, becomes a potential tool to prevent deforestation (Gullison 2003).

SFM certified forest may also potentially prevent forest through consumer behaviour change. Consumer is expected to be willing to pay a price premium for forest products that come from certified forests. This consumer preference for certified forest products with a higher price is an economic incentive for forest owners to implement SFM. An adequate margin generated through certified forest products will incentivize producers to adopt SFM practices (Merry and Carter 1997; Damette and Delacote 2011). By adopting SFM, the owners can also asses and/or enhance and/or maintain a greater market share for certified products. If the price premiums for certified forest products is higher enough, forest owners have an economic incentive to retain their forests and to manage them for sustainable practices, instead of converting them into non-forest land uses (Gullison 2003). Those economic incentives of certified forests can prevent and/or lessen the risk of forest conversion (Karsenty et al. 2008; Ebeling and Yasué 2009), turning into preventing deforestation.

SFM certification has been also a powerful means to promote and enhance environmental awareness. Economic (market), social and political pressures for more environmental-friendly practices and products could encourage and change behaviour of society and government to put environmental-friendly products, as well as awareness of deforestation reduction into consideration of consumers (Tikina and Innes 2008). SFM development could also bridge society and government to improve forest governance by promoting broader stakeholder participation and transparency (Nebel et al. 2005; Muhtaman and Prasetyo 2006). By doing so, issue of environment, including deforestation, will be taken into account during development process. Institutionalization of SFM into such legal and better governance frameworks, which has now been promoted and adopted widely by many governments, is a prospective effort to halt deforestation.

3.2.2. SFM-related Initiatives in Indonesia

The initiation of environmental countermeasure in production forest in Indonesia has started by the 1990s when the Indonesian Selective Felling and Planting System (TPTI) has been introduced and implemented for logging permits. This system regulates allowable cutting (number and diameter of trees), felling cycle, enrichment planting and minimum conservation area within permitted area. In 2000, the government establishes the principles and practices of timber harvesting. Furthermore, to ensure sustainability practices in the field, RIL guideline for Indonesia has been endorsed since 2003 (Elias et al. 2001). The concessionaire has to oblige and follow the Environmental Impact Assessment (EIA) for their entire area (Gustafsson et al. 2007). Recent environmental initiatives have been taken into action as well, such as the Indonesian Timber Legality Verification System (*Sistem Verifikasi Legalitas Kayu* - SVLK) and the ratification of the Voluntary Partnership Agreement (VPA) of the Forest Law Enforcement, Governance and Trade (FLEGT) with the European Union in 2011 (van Heeswijk and Turnhout 2013; Lesniewska and McDermott 2014).

In line with those environmental initiatives for production forest, SFM has already taken place since 1993. In addition to international factor, as described in the previous part of this chapter, international pressure that threats export market for forest products stimulates domestic forest industries to cooperate with the government in responding those environmental issues by developing and adopting SFM. Therefore, it is argued that the development of SFM in Indonesia is characterized by a close coalition between the government and private sector (Elliott and Schlaepfer 2001). Both international and domestic factors play as important driving forces of the development of SFM in Indonesia (Muhtaman and Prasetyo 2006).

Currently, two main SFM schemes presents in Indonesia: the domestic SFM certification scheme and the voluntary (non-state market-driven) SFM certification scheme. The domestic scheme, as explicitly embedded in its name, is legally mandated by the law; and, the C&I has been developed by the government. Developed since 1993, the first version of C&I has been legalized since 2002 and termed as SFM performance assessment for production forest (hereafter so called *the domestic SFM certification*). The most recent version of its C&I was revised in 2014 consisting of 4 indicators, 22 sub-indicators and 89-90 verifiers (Table 10).

Table 10. Indicators, sub-indicators, and verifiers of Indonesia's SFM certification (Source: Decree of the Directorate General of Forestry Utilization No. P.5/VI-BPPHH/2014).

Indicator/	Sub-indicator	Number of verifier	
		LP	PCP
1. Pre-requisites	1.1. Land status	5	5
	1.2. Commitment	3	3
	1.3. Human resources	3	3
	1.4. Capacity of planning, operating, monitoring and evaluation	4	4
	1.5. Free, prior and informed consent	4	4
2. Production	2.1. Spatial planning	3	3
	2.2. Sustainable harvesting	3	3
	2.3. Silviculture	4	4
	2.4. Environmentally technology	4	3
	2.5. Cutting practices	4	4
	2.6. Financial and investment	6	6
3. Ecology	3.1. Protected sites	5	5
	3.2. Land protection and security	4	4
	3.3. Impacts on soil and water	6	6
	3.4. Endangered species	2	2
	3.5. Flora management	3	3
	3.6. Fauna management	3	3
4. Social	4.1. Land tenure/boundary	5	5
	4.2. Corporate social responsibility	5	5
	4.3. Benefit sharing mechanism	5	5
	4.4. Conflict resolution	4	4
	4.5. Labour protection	4	4

Since it is the compulsory scheme for any forest management unit in production forest, the government bears the costs of the first assessment process (MoF 2013*b*). This SFM scheme is the third party type of certification, meaning that assessment is done by the third independent party accredited by the government. Current independent accredited assessors are listed in Table Annex 4. This SFM scheme is used by the government to assess the level of the performance and the obedient of forest production unit towards C&I. Results, then, are utilized by the government as one of consideration to decide the status of forest permits (MoF 2002).

Based on C&I developed by the government, the third party accredited assessor conducts the assessment for a given forest management unit. The assessment will result in the final numerical score, ranging from 0 to 100, for every verifier of all indicators and sub-indicators of C&I. That final numerical score, then, will be categorized into three categorical scores of SFM: good (if the score is more than 80), moderate (score 60-80), and bad (score less than 60). A given forest management unit will be certified if its categorical score falls into good or moderate category. SFM certification is valid for 5 years. To maintain that certified status, surveillance must be conducted annually.

Unlike the domestic SFM certification, the voluntary or market-driven scheme (hereafter called *the voluntary SFM certification*) is endorsed by non-state institution such as LEI, FSC and PEFC. Forest company is free to apply for being certified. As briefly described, although the first experience of voluntary SFM certification was in 1990, the development of forest certification in Indonesia has started since 1993. Currently, both domestic (LEI and IFCC) and international (FSC and PEFC) voluntary SFM certification schemes has been persisting in Indonesia.

Though the domestic and the voluntary SFM schemes have some differences, the reference basis for both is similar, which is C&I (Rametsteiner and Simula 2003). Both schemes are also the third party certification schemes, meaning that assessment is done by the independent accredited assessor. As mentioned earlier, the focus of this analysis is the domestic SFM certification scheme.

3.2.3. Previous Studies

In this global climate change era, the enhancement and the expansion of SFM practices is expected to play more significant roles as one of the main mitigation actions to halt deforestation. However, in relation to SFM, most studies have concerned more about biodiversity aspect. Accordingly, most studies have focused more on voluntary SFM certification scheme rather than the domestic SFM scheme. Since approximately 150 countries all over the world have engaged in the development, promotion and implementation of the domestic SFM scheme (Wijewardana 2008), it is wondering to realize that the domestic scheme has not become interest of studies. Alike fact applies for the case of Indonesia, where most studies has been in the context of voluntary SFM scheme as briefly reviewed in the following paragraphs.

At global level, quantitative studies have no a confirmed conclusion on the relation between the voluntary SFM certification and deforestation. A cross-country fixed-effects panel data analysis for FAO data during 1972-1994 shows that this scheme is negatively correlated to deforestation (Damette and Delacote 2011). Hughell and Butterfield (2008) report positive contribution of voluntary SFM scheme to diminish deforestation in Mayan Biosphere Reserve. However, a CGE analysis with GTAP data shows that major timber producing countries have little incentive to implement forest certification so that it is questionable to expect that voluntary SFM scheme will be globally able to respond deforestation issue (Gan 2005). Accordingly, this notion is supported also by some qualitative studies (Sierra 2001; Fischer et al. 2005; Tikina and Innes 2008; Marx and Cuypers 2010; Bartley 2014) arguing that its expected impact has still been limited in developed countries (Gullison 2003; Cashore et al. 2004; Auld et al. 2008), whereas deforestation has mostly occurred in tropical developing countries.

For Indonesia case, generally the development of the voluntary SFM certification has been far from expectation. At local community-based forest management, a study shows that the development of this scheme can be a means to encourage public participation for SFM practices (Takahashi 2008). By comparing primary forest and certified selective logged forest in East Kalimantan, Arbainsyah *et al.* (2014) confirms that logging practices in certified forest have not resulted in a high deforestation. Though its implementation has had a partial positive effect at the forest management unit level, but its large-scale impacts is significantly limited (Muhtaman and Prasetyo 2006). Even, link between certified forest unit and reduced carbon dioxide emission is not clear (Griscom et al. 2014). Land tenure conflicts have been recognized as a crucial issue causing large-scale forest management units hard to be certified (McCarthy 2012; Obidzinski et al. 2013). From demand side, domestic demand for wood is still dominant rather than international demand. Moreover, international demand for certified wood is still limited (Bartley 2010).

On the other side, the case of the domestic SFM scheme has not been studied widely. However, it is worth noted a qualitative study done by Wijaya et al. (2014). From their interview questionnaire survey, they conclude that the domestic SFM offers some non-economic benefits for the company. Therefore, there are no economic incentives for the company to apply for the domestic SFM.

Relation between the implementation of SFM certification and deforestation is limited. Based on aforementioned voluntary SFM certification cases, their relationship is still inconclusive. Most scholars have a sceptical expectation about its positive impact to tackle deforestation issue. However, there are several empirical studies confirming its positive impacts. Importantly, SFM implementation has increasingly gained stronger supports to play more important role in halting global deforestation.

3.3. Data and Methods

The literature on SFM gives us references about some important elements of studies on SFM implementation. The first element is *effectiveness* that analyses the on-the-ground performance of SFM implementation in relation to the main objective (Elliott 2000; Gulbrandsen 2005), which is to tackle deforestation issue. Similarly, effectiveness can be measured by questioning how far SFM implementation is able to improve the current forest management (Bass et al. 2001). *Efficiency* is the second element of SFM study. It is about to measure the benefits and the costs of SFM implementation, both in monetary and/or non-monetary values (Elliott 2000; Bass et al. 2001). In this cost- benefit analysis, study ranges among the point of views of producers, consumers, or society (Nebel et al. 2005). Thirdly, *equity* aspect is another important topic in which analysis can enquiry who gains and who losses because of the implementation of SFM (Elliott 2000). Study on SFM could also concern about its *credibility*. Viability, legitimation, reliability, conflict of interests, transparency and acceptability of SFM adoption by stakeholders are some issues of this concern (Bass et al. 2001; Nebel et al. 2005). Study on SFM may also be conducted in a broader context, analysing its *impacts* or its positive consequences on social, economic, political and environmental aspects (Elliott 2000). The other side is a study interested more in analysing its *secondary effects* or un-intended side-effects of SFM implementation.

Among those aforementioned criteria, effectiveness is the most element in which most studies have been focused on. Specifically, based the framework developed by Young (1994), Tikina and Innes (2008) further propose more detail elements of effectiveness of SFM, namely problem solving, goal attainment, behavioural effectiveness, process effectiveness, constitutive effectiveness and evaluative effectiveness. Problem solving issue of SFM is clearly understood, which is to deal with deforestation and biodiversity loss issues. Goal attainment is focused on the achievement of C&I and forest certification standards, target of market share, or avoiding public pressure. The focus of behavioural effectiveness is on the behaviour changing of stakeholders because of SFM implementation. While process effectiveness concerns on commitment and adoption to SFM implementation by different stakeholders, constitutive effectiveness more focuses on the acceptability of SFM system. Comparing results or achievement (sustainability, efficiency, equity and robustness) of SFM implementation with other scheme is the interest of evaluative effectiveness. This present analysis focuses on the problem solving of the implementation of SFM certification scheme in relation to deforestation. This is a substantial element that prompts the establishment of SFM system, which is to deal with deforestation and loss of biodiversity issues (Cashore et al. 2004; Marx and Cuypers 2010; Chávez and Cossío 2013).

Two main types of forest permits or concessions dominant in production forest are taken into the analysis, LP and PCP. Score of the domestic SFM certification for each forest management unit are gathered from many sources. However, not whole population can be collected; some are neither available nor accessible. As discussed in the previous section, there are three types of assessment results: (i) numeric score ranging from 0 to 100; (ii) categorical score (good for score more than 80, moderate for score 60-80, and bad for score less than 60); and (iii) binary score (certified for good-moderate categories and not certified for bad category). Because data of numeric score are very few (26 observations) and the interest of this analysis is to investigate the domestic SFM, categorical score is used in this analysis.

Annual forest cover loss extracted from GFC or Hansen dataset (Hansen et al. 2013a) is used as the proxy of deforestation. We generate data of forest cover loss for each forest permit unit by overlapping their geographical boundary with Hansen database. Further, the analysis examines two possible measurements of forest cover loss in each forest unit: amount of loss in ha and ratio of forest cover loss in total forest unit area. Those two dependent variables are regressed on some explanatory variables attributed to forest units, with the main interest in the domestic SFM certification. For the domestic SFM, the reference base is the waiting company (forest permits that are not involved yet in the domestic SFM certification scheme).

Other explanatory variables included are area of forest permits in hectare, the dummy variable for types of forest permits (1-LP and 2-PCP), the dummy variable for the ownership of forest permits (0-company, 1-join operation and 3-state-owned), the average of elevation and the average of slope. Table 11 presents the data and sources; and data summary is reported in Table Annex 5. And, the empirical model is as followings:

$$DEF_{jt} = \beta_0 + \beta_1 SFM_{jt} + \beta_i{}' X_{jt} + \delta_{jt}$$

where *DEF* is forest cover loss in each forest unit, *SFM* is the categorical score of the domestic SFM certification; *X* is vector of explanatory variables, including types of forest permits, area, ownership, elevation and slope; j is forest permit unit; δ is the error term. Spatial variance is controlled by incorporating the dummy variable for island. The year-effects are also controlled. Since the variable of SFM does not largely change over the time, parameters of β are estimated by the random-effects with a robust standard error estimation. Error term is assumed to be normally distributed.

Table 11. Sources of data for SFM certification

Item	Data	Unit	Source	Expected sign
Deforestation	Forest cover loss in 2012	Ha and ratio in total land area	Hansen *et al.* (2013)	Dependent variable
Domestic SFM certification	Categorical score	0-waiting company 1-bad 2-moderate 3-good	Ministry of Forestry, accredited assessor website, company website	Negative
	Year of certified	Year		-
	Validity of SFM certification	Year		-
	Accredited assessor	Name of assessor company		-
Forest permits	Geographical boundary	Spatial boundary	Webgis Ministry of Forestry	-
	Area	Ha		Positive
	Types of permits	1-LP 2-PCP		Negative
	Ownership	1-company 2-join 3-state-owned		Negative
	Year of company establishment	Year		-
	Experience	Year, calculated as the difference between year of 202 and the establishment year		Negative
	Elevation	Meter above sea level	Global Climate Database (www.worldclim.org)	Negative
	Slope	In degrees	Global Climate Database (www.worldclim.org)	Negative
Others	Administrative boundary	Spatial boundary	Global Administrative Area Database (www.gadm.org)	-

3.4. Results and Discussion

Forest cover loss within forest permit unit is approximately ranging approximately 219.34 ha within LP and around 721.80 ha within PCP, respectively over the period of study. Our database records that the mean of area of LP is around 82.87 thousand ha, while the average area of PCP is around 42.42 thousand ha. Most of observations or around 92.28% are on the status of company, while 2.63% and 5.09% are managed under the joint and the state-owned ownerships, respectively. In our database, there are only 346 permits that are already involved in the domestic SFM certification, while the rest (or around

95.34%) are in the waiting position to participate in the domestic SFM scheme. Table 12 shows more detailed description of the SFM certification category by forest permit types and the ownership.

Our data also shows that only 20 forest management units are certified by FSC, covering approximately 2.47 million ha. Both number of units and amount of area of FSC-certified are much larger than those in 2009 reported by Bartley (2010), which were 9 units and around 1.09 million ha. All of FSC-certified units are private forest permits, consisting of 16 LP and 4 PCP.

Table 12. Detailed observations of the domestic SFM category by the types and the ownership status

Types	SFM				Total
	0-waiting	0-bad	1-moderate	2-good	
LP	3,981	16	114	127	4,238
PCP	3,096	6	2	81	3,185
Total	7,077	22	116	208	7,423

Regression results are reported in Table 13 for all observations and Table 14 for LP and PCP, respectively. The robustness check is done with the ratio between forest cover loss in the total forest unit area as the dependent variable. The measurement of SFM certification the categorical score (0-waiting as the reference, 1-bad, 2-moderate and 3-good). Signs of the other control variables are in consistencies with the expectation. PCP tends to experience more losses of forest cover. This result is in line with the results of the previous chapter. The wider the area, the more forest cover loss as indicated by the positive significant of this parameter. Furthermore, the analysis controls also site-specific factor, which are the altitude and the slope. Results show that both variables are negatively correlated with forest cover loss.

Table 13. Estimation results of the domestic SFM certification: all observations (Note: robust standard errors are in parentheses; significance at 1%, 5%, and 10% are denoted by ***, ** and *, respectively)

VAR.	Ha	(se)	Ratio	(se)
d1.SFM-bad	650.2377	(549.850)	-0.0029	(0.002)
d2.SFM-moderate	-96.9038***	(33.046)	-0.0020***	(0.001)
d3.SFM-good	33.5587	(153.870)	-0.0002	(0.002)
d2.TYPE-PCP	466.4252***	(114.556)	0.0065***	(0.001)
d2.OWN-join	-36.9442	(489.270)	-0.0096***	(0.003)
d3.OWN-sate	3.9782	(100.408)	0.0008	(0.001)
AREA	0.0109***	(0.003)	0.0000	(0.000)
ELEV	-0.5517*	(0.301)	-0.0000**	(0.000)
SLOPE	7.3197	(32.376)	-0.0011***	(0.000)
d2.Maluku	51.6530	(78.167)	0.0005	(0.001)
d3.Papua	-1,526.5524***	(321.397)	-0.0058***	(0.001)
d4.Sulawesi	104.5435	(90.386)	0.0034***	(0.001)
d5.Sumatera	504.8247***	(127.669)	0.0121***	(0.001)
d.YEAR	Yes		Yes	
Constant	-553.9674***	(212.337)	0.0022**	(0.001)
Observations	7,410		7,410	
Wald-chi2	166.80***		589.14***	

For all observation models (see Table 13), results show that the domestic SFM has no significant impacts on forest cover loss, but the moderate category. In these two models, the forest cover loss within the moderate SFM forest permits is significantly lower than that within the waiting forest permits. However, forest cover loss within the bad and the good SFM forest permits are not significantly different with that within the waiting forest permits.

When the observations are run separately by the types of forest permits (LP and PCP) as reported in Table 14, the potential effect of the domestic SFM is observed within the bad SFM of LP. On the other side, there are no robust results of the domestic SFM for PCP sample data, except for PCP in hectare dependent variable.

Table 14. Estimation results of the domestic SFM certification: LP and PCP (Note: robust standard errors are in parentheses; significance at 1%, 5%, and 10% are denoted by ***, ** and *, respectively)

VAR.	Ha_LP	(se)	Ratio_LP	(se)
d1.SFM-bad	-108.9791***	(33.488)	-0.0027***	(0.001)
d2.SFM-moderate	-46.3762	(32.133)	-0.0007	(0.000)
d3.SFM-good	-26.9992	(34.723)	-0.0007	(0.001)
d2.TYPE-PCP	0.0000	(0.000)	0.0000	(0.000)
d2.OWN-join	0.0000	(0.000)	0.0000	(0.000)
d3.OWN-sate	202.7232	(164.972)	0.0027	(0.002)
AREA	0.0020***	(0.000)	0.0000	(0.000)
ELEV	-0.3765***	(0.091)	-0.0000***	(0.000)
SLOPE	-29.0522**	(12.009)	-0.0005***	(0.000)
d2.Maluku	-56.2518	(36.458)	-0.0006	(0.001)
d3.Papua	-422.6789***	(76.246)	-0.0037***	(0.000)
d4.Sulawesi	244.4617***	(68.648)	0.0032***	(0.001)
d5.Sumatera	117.2085	(76.144)	0.0041**	(0.002)
d.YEAR	Yes		Yes	
Constant	186.2130***	(42.044)	0.0045***	(0.001)
Observations	4,238		4,238	

(Table 14 continued)

VAR.	Ha_PCP	(se)	Ratio_PCP	(se)
d0.SFM-waiting	2,007.6037**	(962.024)	-0.0028	(0.002)
d1.SFM-bad	318.6673	(334.268)	0.0009	(0.007)
d2.SFM-moderate	264.3769	(427.586)	0.0023	(0.005)
d2.TYPE-PCP	0.0000	(0.000)	0.0055***	(0.001)
d2.OWN-join	-222.5876	(214.447)	-0.0093***	(0.003)
d3.OWN-sate	-92.2741	(149.417)	-0.0010	(0.002)
AREA	0.0238***	(0.003)	0.0000*	(0.000)
ELEV	-0.6303	(0.490)	-0.0000	(0.000)
SLOPE	-57.5511	(57.256)	-0.0031***	(0.001)
d2.Maluku	46.1615	(165.965)	0.0013	(0.002)
d3.Papua	-3,219.9400***	(896.189)	-0.0152***	(0.002)
d4.Sulawesi	429.1324*	(243.255)	0.0083***	(0.003)
d5.Sumatera	592.9594***	(121.939)	0.0140***	(0.002)
d.YEAR	Yes		Yes	
Constant	-680.8607***	(152.280)	0.0000	(0.000)
Observations	3,172		3,172	

Empirical results of this current analysis show that the domestic SFM certification has a negative limited effect to reduce forest cover loss, as partially observed in all-models and in LP-models. However, a robust correlation is not be confirmed. These results are in line with other studies arguing that the implementation of SFM in Indonesia has had a partial positive effect at the forest management unit level, but its large-scale impacts is significantly limited (Muhtaman and Prasetyo 2006). Following Obidzinski et al. (2013) and Bartley (2010), this analysis argues that the partial roles of the domestic SFM certification to reduce forest cover loss are due to the fact that most forest permits have been established in the previously forested areas and the issue of law enforcement and moral hazard in the SFM scheme.

3.5. Concluding Remarks

SFM has been promoted since 1993 and implemented since 2002 as one of the important efforts to reduce deforestation in Indonesia. There are two main schemes of SFM, which are the domestic SFM or the government-established scheme and the market-driven scheme. Although it has been more than two decades, there are few studies investigating those mitigating impacts on deforestation. This chapter is to investigate whether the domestic SFM certification is able to mitigate deforestation in Indonesia. Unlike previous studies which had been concerned about the market-driven SFM scheme, this analysis addresses factors that explain the performance of the domestic SFM scheme.

Panel random-effect estimation with robust standard errors results in a conclusion that we cannot confirm a robust impact of SFM certification in mitigating deforestation, but its limited effect is partially observed. Since the government establishes this scheme as one of the deforestation mitigations, these results call the government to do a comprehensive evaluation of this scheme.

Appendix

Table Annex 4. List of current accredited assessors for SFM certification in Indonesia.

Accredited Assessories for SFM certification	Accreditation Number
Ayamaru Sertifikasi	LPPHPL-001-IDN
Sarbi International Certification	LPPHPL-004-IDN
Sucofindo International Certification Services	LPPHPL-005-IDN
Almasentra Certification	LPPHPL-006-IDN
Rensa Global Trust	LPPHPL-007-IDN
Mutuagung Lestari	LPPHPL-008-IDN
Forescitra Sejahtera	LPPHPL-009-IDN
Equality Indonesia	LPPHPL-013-IDN
Multima Krida Cipta	LPPHPL-015-IDN
TUV Rheinland Indonesia	LPPHPL-016-IDN
Global Resource Sertifikasi	LPPHPL-017-IDN
Transtra Permada	LPPHPL-018-IDN
Trustindo Prima Karya	LPPHPL-019-IDN

Table Annex 5. Data summary: SFM certification

Variable	Obs	Mean	Std. Dev.	Min	Max
DEF_ha	7423	434.9304	1478.894	0	31507.98
DEF_rat	7527	0.009281	0.021881	0	0.595142
SFM	7423	0.118281	0.551101	0	3
dTYPE	7423	1.429072	0.494977	1	2
dOWN	7410	1.12807	0.462008	1	3
AREA_ha	7423	65515.72	77392.43	0.000167	654725.7
ELEV	7423	204.0435	211.0048	6.567857	1390.817
SLOPE	7423	2.105968	2.023481	0.030573	8.950515
dYEAR	7423	2007	3.741909	2001	2013
dISLAND	7423	2.556918	1.728067	1	5

CHAPTER IV. TO WHAT EXTENT DOES AGRICULTURAL PRODUCTIVITY IMPROVEMENT AFFECT DEFORESTATION?

4.1. Background and Objective

Indonesia is the largest producer country of palm oil with the production approximately 26.02 million tons in 2012 (FAO 2014). Oil palm area has expanded exponentially since 1990s (Miyake et al. 2012); current progress of oil palm area is depicted in Figure 7 (MoA 2015). Furthermore, Ministry of Agriculture predicts that its area will be increasing to be nearly 10.47 million ha and 10.96 million ha in 2013 and 2014, respectively. As one of the most profitable land uses in the tropics (Barcelos et al. 2015), the high economic return of oil palm, incentivized by the central and local government supports, has boosted extensive investment (Fitzherbert et al. 2008; Gaveau et al. 2009) for oil palm development (Abdullah and Hezri 2008).

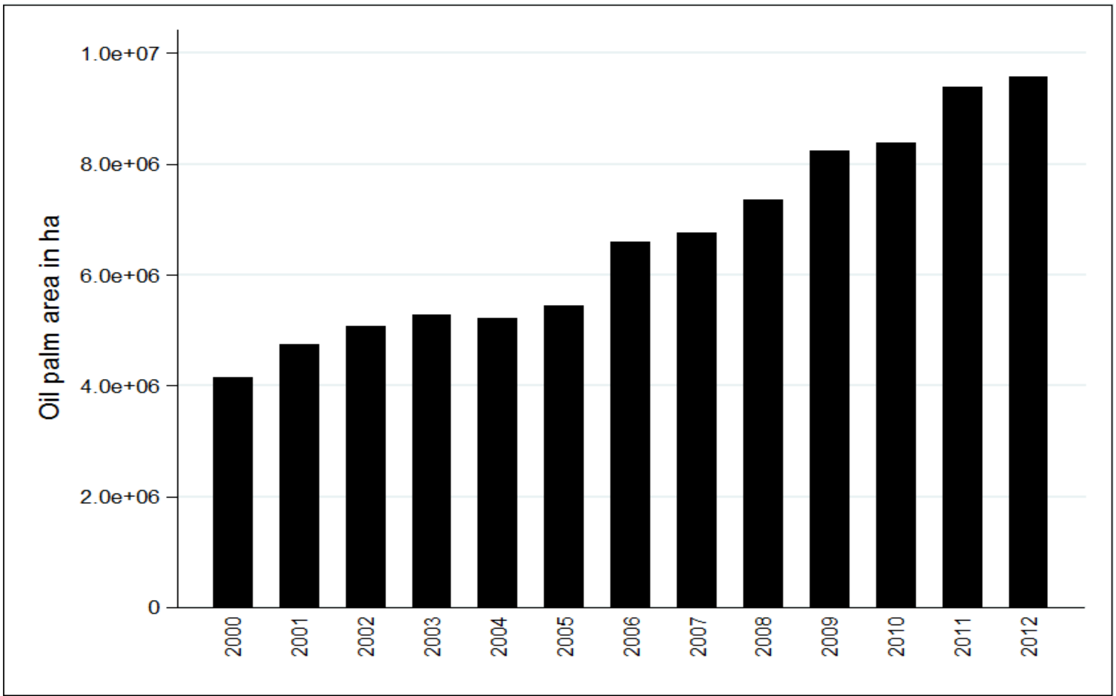
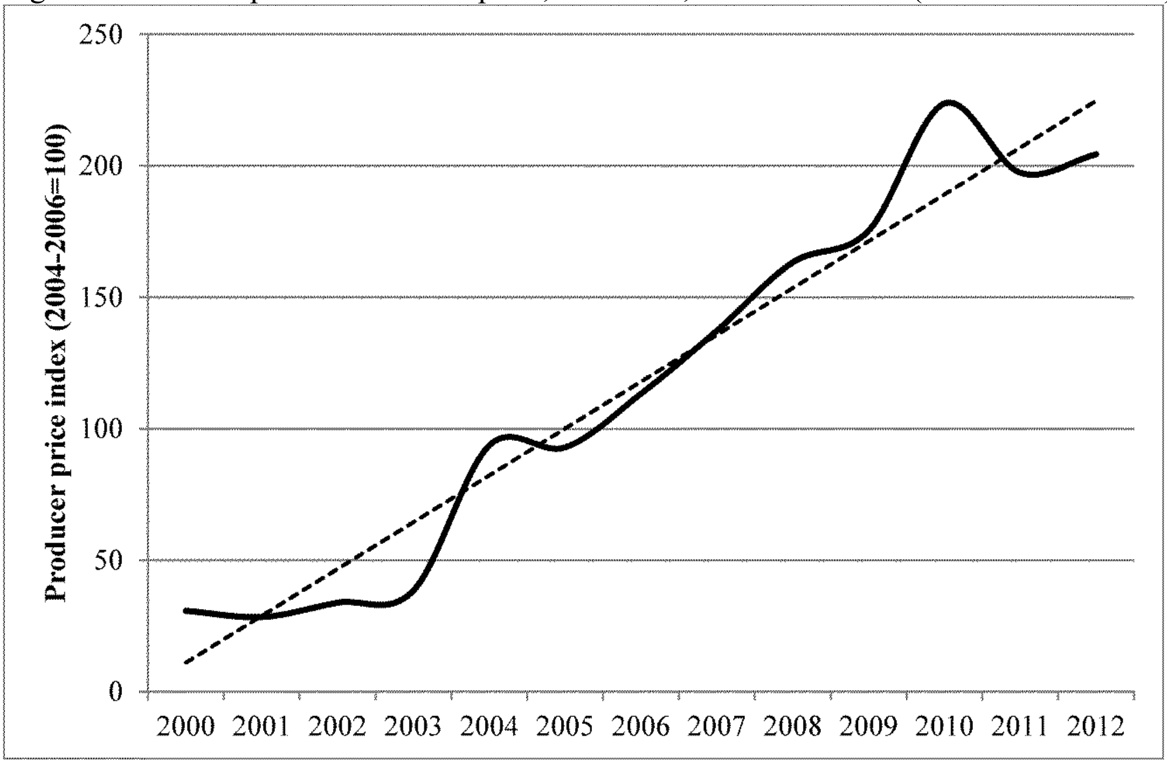


Figure 7. Oil palm area, 2000-2012 (Source: MoA 2015)

The government of Indonesia has set targets for food and tree crop production (Verchot et al. 2010), in which annual crude palm oil is targeted to increase production of crude palm oil to 40 million tons by 2020 (WB 2011). Provincial and district governments have also plans to develop around 20 million ha of oil palm plantations (Colchester et al. 2006). New large oil palm plantations would be occurring in Papua where most of proposed land uses are for oil palm plantation in the development of the food and energy estate (MIFEE) program (Brockhaus et al. 2012; Obidzinski et al. 2013) and the pro-poor rural development program (USAID 2009). Furthermore, the promotion of biofuels has urged the government to develop approximately 4 million ha of oil palm plantation for 2016-2025 (Greenpeace 2009; Brockhaus et al. 2012).

Important contributions of oil palm industry for economic growth, job and income generation and government revenues have attracted government and international development organizations to further develop its plantation and industry (Zen et al. 2005; WB 2011; Obidzinski et al. 2013). Involvement of private investment has been motivated by its competitiveness (such as lower input requirements, lower land requirement and higher productivity) compared to other vegetable and fat oils. Its high profitability, increasing market demand, low production cost and increasing price (Figure 8) indicates that an increasing trend of oil palm area will be witnessed in the future. Oil palm has been one of the top expanded crops (Stevenson et al. 2011).

Figure 8. Producer price index of oil palm, Indonesia, 2004-2006=100 (Source: FAO 2015)



Rapid agriculture expansion in Indonesia (Barber and Schweithelm 2000; Margono et al. 2012), especially oil palm (Casson 2000; MoF 2008; Hansen et al. 2009), has brought significant pressure on forest. Oil palm expansion has been considered to contribute a half of agricultural expansion (Wicke et al. 2011), as well as the major cause of deforestation in Indonesia. Fitzherbert et al. (2008) indicates that over half of oil palm expansion during the period of 1990-2005 caused forest clearance. Several regional studies for Kalimantan (Carlson et al. 2012*a*, *b*; Gaveau et al. 2013) and Sumatera (Gaveau et al. 2009; Lee et al. 2014*b*) result in similar findings. In Sumatera case, a simulation analysis is done by Lee et al. (2014) finding that most deforestation is driven by large-scale oil palm companies. At national level, result from Abood et al. (2014) shows that contribution of oil palm on deforestation ranks the third and the second for total dioxide emissions compared to logging permits and plantation conversion permit areas. The most recent study predicts that granting oil palm permit will potentially increase site-level deforestation rate nearly by 17-127% (Busch et al. 2015). At national level, however, Wicke et al. (2011) suggests that it does not appear to be the major cause of deforestation. A micro survey study in Jambi, Sumatera also reveals a similar conclusion of insignificant impact of oil palm on deforestation (Gatto et al. 2015). Oil palm is a striking example of how agricultural expansion has threatened forests (Sheil et al. 2009).

In conjunction with area expansion, increasing oil palm productivity is another main strategy of oil palm development (MoA 2012). In this sense, various technological and managerial innovations have been examined and developed to increase the yield. Under *Program Peremajaan Tanaman* by replacing the un-productive with the new high-yielding oil palm), the government delivers some supports to improve oil palm productivity, including fertilizer, pesticide and water management. Furthermore, several productivity improvement aspects are also attributed more modern technologies, such as tissue culture, molecular and genetic engineering and crop germplasm improvement (Evenson and Rosegrant 2003; Wahid et al. 2005; Stevenson et al. 2013). Several best management practices of managerial aspects such as integrated crop system with livestock can also enhance oil palm productivity and profitability (Devendra 2009).

Recently, a stronger environmental scrutiny for oil palm industry stimulates several world-wide oil palm companies to commit with environmental countermeasures (Barcelos et al. 2015), such as the Roundtable on Sustainable Palm Oil (RSPO), the Indonesian Sustainable Palm Oil (ISPO) or the action of zero deforestation or no expansion towards forest areas in their operation areas (Greenpeace 2013; Guardian 2015). Raising agricultural productivity has also been proposed by scholars to counteract environmental issues on oil palm development (Angelsen and Kaimowitz 2001*a*; Miyake et al. 2012; Hoffmann et al. 2014). Empirical studies at global level estimates that it can avoid forest conversion to oil palm plantation (Koh et al. 2009) or even reduce deforestation rate (Barbier and Burgess 1997). Increasing productivity has been also adopted by government and international development organizations to be an essential strategy in mitigating environmental issues, especially deforestation and greenhouse gas emissions (WB 2011). However, the relationship between agricultural productivity and forest change is complex. The improvement of oil palm productivity could be both opportunities and risks for forest (Carr et al. 2005; Ewers et al. 2009; Newton et al. 2013).

In sum, expanding area and increasing yield/productivity are two main strategies for reaching the production target in the development of the oil palm industry. Since area expansion will be restricted to some degrees of the lack of land availability and the moratorium on forest conversion (Potter 2015), increasing productivity will be an important decision for reaching the target of production. The latter strategy is directed also to mitigate environmental impacts of oil palm plantation. Both strategies have important links to deforestation. While positive correlation between oil palm expansion and deforestation are reported by most studies, the relationship between oil palm productivity and deforestation is still inconclusive, theoretically and empirically. Hence, unlike other previous empirical studies that put attention more on the area expansion, this present study focuses on investigating to what extent improved oil palm productivity correlates with deforestation in Indonesia. Following the strategy adopted by the government and international development institutions, this present analysis expects that improved oil palm productivity can reduce deforestation. The rest of the paper is outlined as followings. Theoretical and empirical studies on agricultural expansion, agricultural productivity and deforestation are reviewed in the next section. Its discussion covers some important notions of the land saving/sparing effects or the Borlaug hypothesis and the land consuming/rent effects or the Jevons paradox. Regression analysis derived from the STIRPAT model results in positive correlations between oil palm productivity and forest cover loss in Indonesia. Further discussion and policy implications of the empirical results are elaborated in the last section.

4.2. Agricultural Expansion, Agricultural Productivity and Deforestation

Especially in developing and forest tropical countries, agriculture expansion has been cited as the major cause of forest resource depletion (Benhin 2006; Laurance et al. 2014). With the global extent of cropland grows fast (Grassini et al. 2013), agricultural expansion gives very strong pressure on tropical ecosystem (Tilman et al. 2001; Gibbs et al. 2010). In this context, an improvement in agricultural technologies is one of win-win solutions. Agricultural technology progress that improves agricultural intensification turns into less demand for agricultural land and less pressure on forest, known as the Borlaug hypothesis (Angelsen and Kaimowitz 2001*b*). Some empirical studies find that agricultural technologies can prevent agricultural expansion and save forest land from being converted into agricultural land (Evenson and Rosegrant 2003; Borlaug 2007; Stevenson et al. 2011). They, even, contributed to reforestation in the American South (Rudel 2001). However, several empirical studies show opposite results, confirming the Jevon's paradox (Stevenson et al. 2011), They find that higher agricultural profitability induced by increased agricultural productivity tends to encourage higher agricultural expansion, leading to more pressure on forest. Some case studies in Angelsen and Kaimowitz (2001a) support this argumentation. Agricultural technological improvements also make more land suitable and feasible for agriculture, leading to higher agricultural expansion (Grainger et al. 2003). Changes in agricultural landscapes induced by technological progress may present both opportunities and risk to forest (Newton et al. 2013). Ambiguous empirical results suggest that additional empirical evidence tested the Borlaug hypothesis or the Jevon's paradox is essentially needed.

Technological change can take several forms. From output-input point of view, technological progress may increase by producing more outputs with the same amount of inputs or producing the same amount of outputs with fewer inputs. New technology can also be approached from profit point of view when it can increase net profits. Technological change can also be classified on how it is measured: labor-intensive or labor-saving, capital-intensive or capital-saving, pure yield increasing, and land saving technologies. More detail discussion is provided in Angelsen et al. (2001).

Likewise, two main effects of agricultural technologies are discussed: the land saving effects and the land rent effects (Stevenson et al. 2011). The former is about the Borlaug hypothesis connecting between agricultural technology change, agricultural productivity, agricultural intensification, agricultural expansion and forest conversion. To produce a fixed amount of agricultural commodity, production process needs less agricultural land. This saved land will lessen agricultural expansion; and, forest conversion can be prevented. Against the former effects, the latter or the Jevon's paradox, which is also equal to rebound effect (Pirard and Belna 2012), stipulates that new agricultural innovation improves productivity or diminish production costs. It will bring agricultural activity more profitable relative to other land uses. This increasing land rent affects negatively to forest cover, since high profit will encourage agricultural expansion. Summarized from (Angelsen and Kaimowitz 2001*c*), Table 15 presents possible positive and negative impacts of agricultural technologies on deforestation.

In relation to deforestation, this present analysis is intended to focus on land saving agricultural technology that increases outputs within the same amount of land, or produces the same amount of outputs over fewer lands. This type of technology, then, can potentially reduce agricultural expansion and save forest. Based on a cross-country data in 1950-2000, agricultural intensification had saved nearly 1.2 billion hectares of forest (Borlaug 2007). Similar association is found by Shively and Pagiola (2004) who investigates rice intensification and forest clearing in the Philippines, which coincides with a theoretical analysis by Jayasuriya (2001). However, in the case of tree crops, the latter author suggests that their productivity improvements will be likely to aggravate forest. Insignificant correlation is found by Rudel et al. (2009).

Table 15. Hypothesizing agricultural productivity improvements on deforestation (Source: Angelsen and Kaimowitz 2001)

Cases	Impacts on forest cover		Note
	Positive	Negative	
The subsistence case	New agricultural technologies – lower production costs – higher agricultural income – concentration of rural labor in agriculture – reduced forest land encroachment.	New agricultural technologies – incentive to expand agricultural land –forest conversion. Rural economic development – rural-in-migration – more pressure on forest.	Micro level.
The economic development case	Improved agricultural productivity – human welfare – higher off-farm jobs and environmental awareness – less forest cover loss.	Economic growth – better infrastructure and higher demand on agricultural products – agricultural encroachment – higher forest cover loss.	Global (macro) level; related to Environmental Kuznets Curve (EKC) for deforestation and forest transition.
The land degradation-deforestation case	New agricultural technologies – more sustainable farming – maintained agricultural productivity without degrading the land resources – less forest clearing.	Agricultural intensification is more costly than extension – more forest clearing.	

Agricultural expansion and deforestation in Indonesia have motivated some studies. Considering rapid expansion of tree crops commodities has grown rapidly (Newton et al. 2013), scholars convince that these trends will put greater pressure on remaining forests (Wirsenius et al. 2010). Results of Ruf (2001) for the case of cocoa in Sulawesi supports this finding. However, the introduction of rubber production in swidden and fallow lands is beneficial in stimulating reforestation in Kalimantan (de Jong 2001). In the case of oil palm expansion, most studies, as briefly reviewed in the first section, confirm its deleterious impacts on forest cover with in an exception of Wicke et al. (2011). Differently, the focus of this study is not only area expansion of oil palm, but also its productivity improvement in relation to forest cover loss.

4.3. Methods and Data

There is a global agreement that deforestation is an anthropogenic issue (IPCC 2007; Gaveau et al. 2009), through which various intertwined proximate and underlying factors are attributed (Kaimowitz and Angelsen 1998; Geist and Lambin 2001). Along with demographic, economic activities, political institutions, attitudes and believes, agricultural technology has been taken into a strong consideration to play a critical role on the center stage of the development agenda, which is the competition for global agricultural land and forest resource (Stevenson et al. 2011).

To analyze association between agricultural technology and deforestation, IPAT approached frames this analysis. This framework specifies that environmental impacts, here is deforestation, are the multiplicative function of their key driving factors, namely population, affluence and technology (Ehrlich and Holdren 1971). As deforestation is considered as an anthropogenic issue, this analytical framework has been considered as a comprehensive approach to the driving forces of such an environmental issue (Meyer and Turner II 1992) or for analyzing human dimensions on the environment (Stern et al. 1992). In environmental studies, this framework has evolved and been reformulated into several modifications, including ImPACT (Waggoner and Ausubel 2002), IPBAT (Schulze 2002) and STIRPAT (York et al. 2003). It has been also employed by some empirical studies for various different environmental issues, such as carbon emissions (York et al. 2003; Poumanyvong and Kaneko 2010), air quality (Cramer 1998) and energy footprint (York et al. 2003; Fan et al. 2006; Li et al. 2012). In the case of forestry, Knight and Rosa (2011) uses it to analyze fuel consumption, as the environmental indicator leading to biodiversity loss, in developing countries.

In this present study, to test the hypothesis, the STIRPAT (STochastic Impacts by Regression on Population, Affluence and Technology) model is used. The basic multiplicative function of STIRPAT for panel data is as followings:

$$I = P_{it}^{\gamma_1} * A_{it}^{\gamma_2} * T_{it}^{\gamma_3}$$

$$\ln(I_{it}) = \gamma_0 + \gamma_1 * \ln(P_{it}) + \gamma_2 * \ln(A_{it}) + \gamma_3 * \ln(T_{it}) + \sigma_{it}$$

where *I* is environmental impact, which is deforestation in this analysis; *P* is population; *A* is affluence represented by per capita income; *T* is technology; γ_1, γ_2 and γ_3 are the parameters to be estimated; σ is error term; and *i* and *t* are province and year, respectively.

Generally, *T* is typically included in the error term since there is no widely accepted the single measure for it (York et al. 2003; Knight and Rosa 2011). Since this analysis is interested to estimate the parameter *d*, hence, *T* is disaggregated by including the variable of oil palm productivity in the STIRPAT model (York et al. 2003). Oil palm productivity refers to land productivity of crude palm oil measured by the amount of crude palm oil harvested per unit cultivated area of oil palm plantation (Rudel 2001; Koh 2007).

In addition, oil palm area and urban population are controlled in the model. Furthermore, panel-specific effects, *v*, and time-specific effects, *m*, are controlled by developing dummy variables for island and year. The empirical model is presented below:

$$\ln(DEF_{it}) = \gamma_0 + \gamma_1 * \ln(POP_{it}) + \gamma_2 * \ln(GRDPcap_{it}) + \gamma_3 * \ln(PALMA_{it}) + \gamma_4 * \ln(PALMY_{it}) + v_i + m_t + \rho_{it}$$

where *DEF* is deforestation measured by forest cover loss in ha; *POP* is number of population; *GRDPcap* is per capita GRDP in Rp 000/capita at 2000 constant price; *PALMY* is oil palm productivity in kg/ha of crude palm oil; *PALMA* is oil palm area in ha; γ_0 is a constant; ρ is the error term; and *v* and *m* are panel- and time-fixed effects.

All variables are taken as their normal logarithmic values, so that the parameter of dependent variable refers to ecological elasticity as the responsiveness or sensitivity of environmental impacts to a change in any of the driving force (York et al. 2003). In this analysis, it is the proportional change in a forest cover loss from a change in explanatory variable with other factors held constant. The main interest of this study is ecological elasticity of oil palm productivity, expecting that improved oil palm productivity will reduce forest cover loss.

Theoretically, the effect of agricultural productivity on deforestation is mediated through agricultural area expansion. Consequently, following literatures (Imai et al. 2010), the Causal Mediation Analysis has been conducted to estimate the parameters, in which the treatment is oil palm productivity, the mediator is oil palm area, and the outcome is forest cover loss. Total effects of oil palm productivity improvement on forest cover loss are decomposed into its average causal mediated effects and its average direct effects. Estimation is based on the linear regression with 1000 simulation. Furthermore, sensitivity analysis is also calculated in this analysis. Multi-collinearity issue is checked by considering, mainly, their variation inflation factor (Table Annex 6).

Data covers all provinces in Indonesia. However, to reduce the bias, the analysis excluded provinces in Java and Bali, leaving 26 out of 33 provinces. It is annual data from 2000-2012. Data of forest cover loss (in 10% and 30% tree cover threshold) is extracted from Hansen et al. (2013). Both combinations of the dependent variables are to check the robustness of estimation. The other data is collected from Central Statistics Agency (BPS) and Ministry of Agriculture. Table 16 presents the data, its sources and their expected signs; while data summary is reported in Table Annex 7.

Table 16. Data, data sources and expected signs

Variables	Symbol	Unit	Source	Expected sign
Dependent variable				
Forest cover loss	DEF	Ha at 10% and 30% threshold of canopy	Hansen et al. (2013)	-
Independent variables				
GRDP per capita at 2000 constant price	GRDPcap	Rp 000/capita	BPS	Positive
Population	POP	Number of population	BPS	Positive
Oil palm area	PALMA	Ha	Ministry of Agriculture	Positive
Oil palm productivity (crude palm oil)	PALMY	Kg/ha	Ministry of Agriculture	Negative

4.4. Results and Discussions

At national level, oil palm area has increased over the period of study, as well as at regional level with in exception of Lampung and provinces in Sulawesi and Papua (Figure 9). Due to data availability, provinces in Maluku and Nusa Tenggara are not displayed. Spatially, oil palm area has not been evenly distributed; rather it has been concentrated in Sumatera and Kalimantan islands, especially in Riau, Sumatera Utara, Sumatera Selatan, Jambi, Sumatera Barat, and all provinces in Kalimantan. Oil palm area by province is given in Figure Annex 4. Temporally, the development of oil palm plantation has started in Sumatera. And, currently it has taken place in Kalimantan. Recognizing such MIFEE program (Obidzinski et al. 2013), oil palm in Papua will be just in the near future.

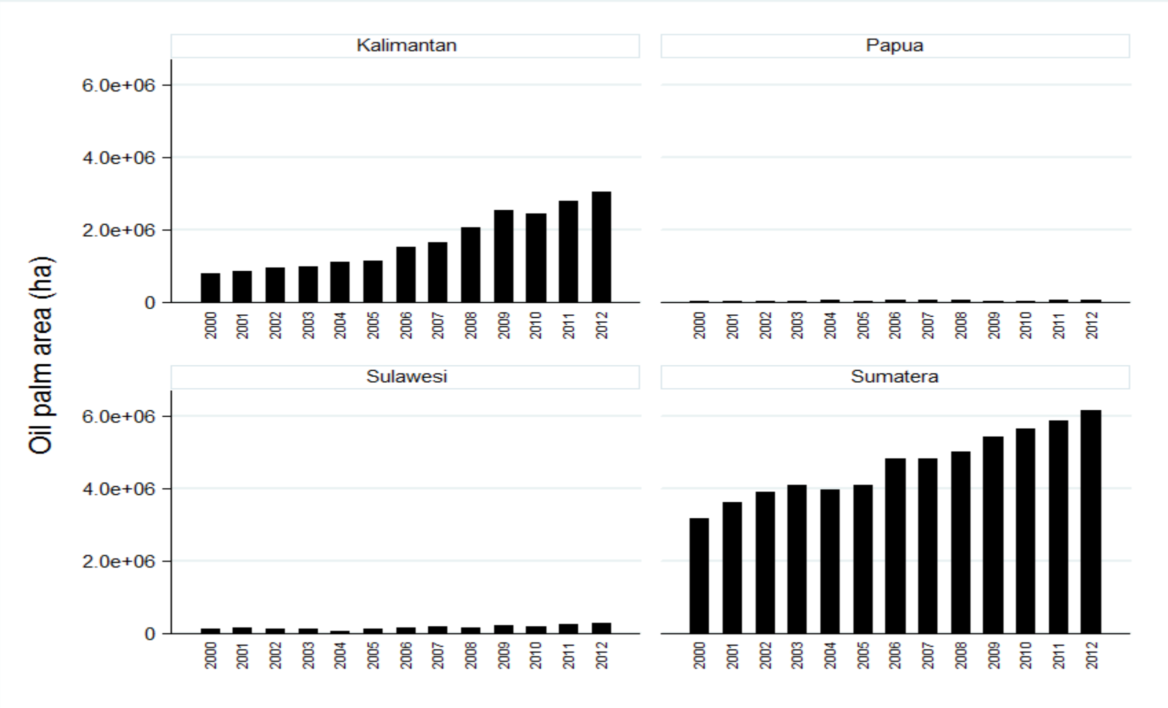


Figure 9. Oil palm area by island in ha, 2000-2012 (Note: data in several provinces/regions is unavailable; Source: Source: MoA 2015)

As area increases, oil palm productivity has improved from around 2.55 tons/ha in 2000 to 3.44 tons/ha in 2012 (Figure 10), with average productivity nearly 2.99 tons/ha over the period of study. This level will reach the global average productivity, which is around 3.5 tons/ha (Barcelos et al. 2015). At regional level, increasing productivity has been found in all islands except Sulawesi (Figure 11), especially Sulawesi Tenggara where its productivity seems to be stable. Unlike the spatial distribution of its area, among regions have relatively similar level of productivity, ranging from 2.54 tons/ha in Papua to 3.16 tons/ha in Sumatera over period of study. Productivity by province is given in Figure Annex 5. This fact indicates that the future expansion to other regions will not be restricted by its productivity. In the other word, new expansion can potentially be feasible, in terms of productivity, elsewhere.

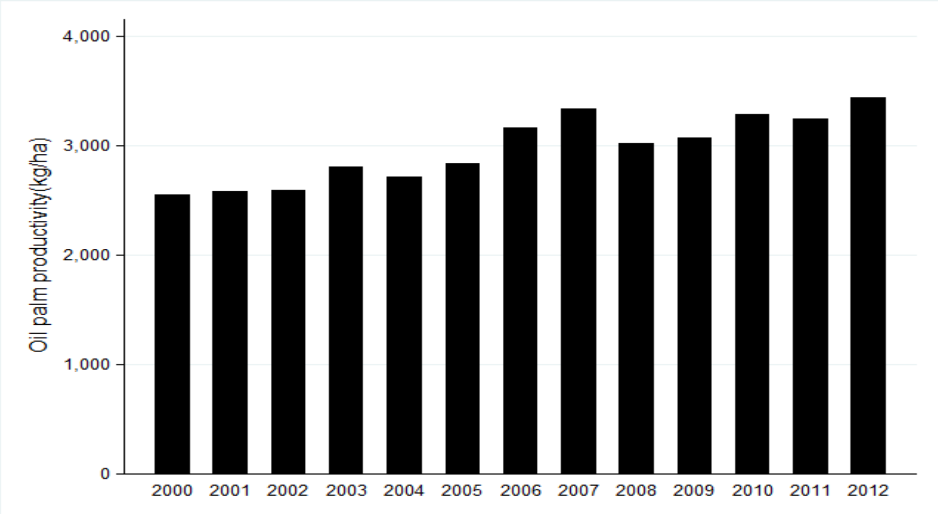


Figure 10. Oil palm productivity in kg/hectares, 2000-2012 (Source: MoA 2015)

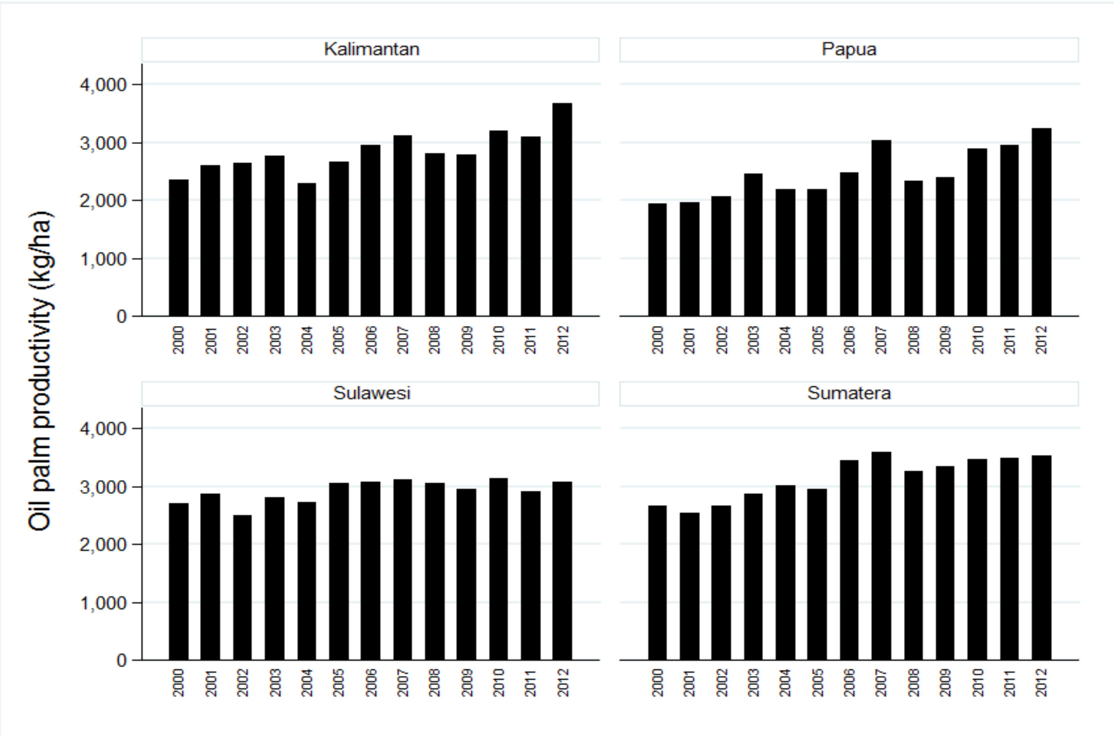


Figure 11. Oil palm productivity by island in kg/hectares, 2000-2012 (Note: data in several provinces/regions is unavailable; Source: MoA 2015)

The estimation results are reported in Table 17, and the sensitivity analysis is shown in Figure 12. To further check the robustness of the results, exercises have been done with two different thresholds of forest cover loss: 10% and 30% threshold of canopy. Results show that the average effect of the oil palm productivity on forest cover loss that operates through the oil palm area expansion is approximately 1.103. The estimates of the average direct effect of oil palm productivity is around 0.951. Based on these results, since the total effects are around 2.055, the analysis estimates that around 53.8% of the total effect of the oil palm productivity improvement on forest cover is mediated through the oil palm area expansion.

Table 17. Average mediated effects, average direct effects and total effects of oil palm productivity on forest cover loss (*** p<0.01, ** p<0.05, * p<0.1.)

Effects	10% canopy			30% canopy		
	Estimate	Lower	Upper	Estimate	Lower	Upper
Average causal mediated effects	1.103***	0.773	1.474	1.099	0.744	1.498
Average direct effects	0.951***	0.456	1.472	0.95	0.447	1.451
Total effects	2.055***	1.545	2.556	2.048	1.532	2.573
% of total effects mediated	0.538***	0.381	0.735	0.535	0.374	0.745

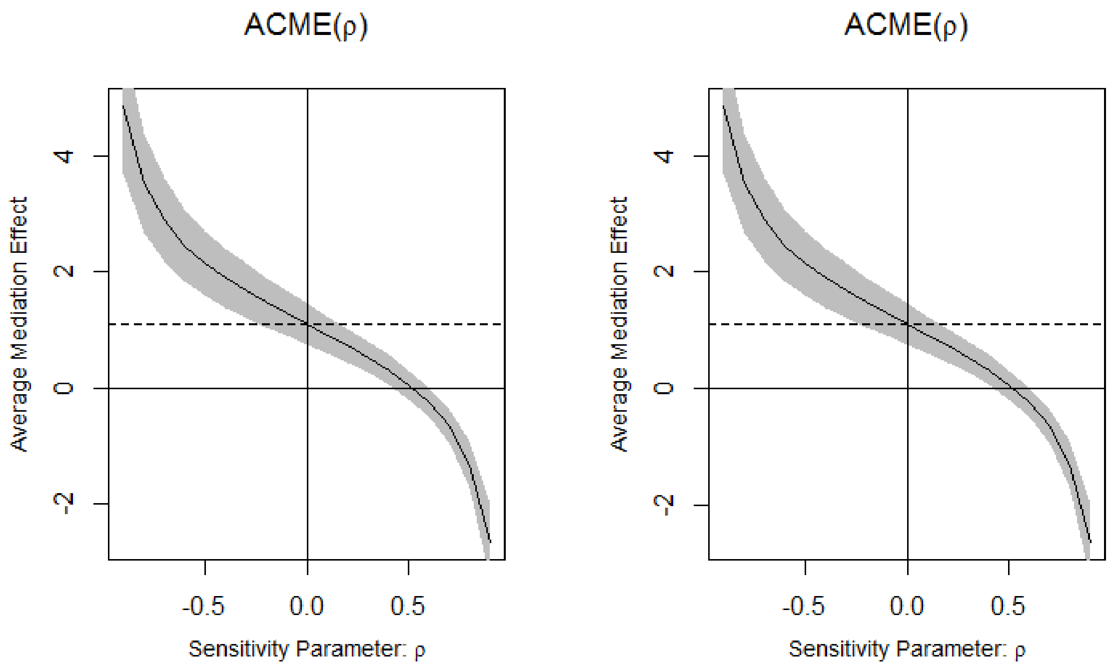


Figure 12. Sensitivity parameter of the average causal mediated effect (ACME) of oil palm productivity: i) 10% canopy and ii) 30% canopy.

From the original equation of the Causal Mediation Analysis, reported in Table 18, the elasticity of forest cover loss to both the oil palm productivity and the oil palm area can be derived. Signs of all control variables are stable and consistent with expectation. In general, there are two models, 10% canopy and 30% canopy. All control variables (population and provincial GDRP) are positively significant. The elasticity of forest cover loss to the oil palm area is around 0.44. This result is in line with the expectation and coincides with most empirical studies (Casson 2000; MoF 2008; Gaveau et al. 2009, 2013; Hansen et al. 2009; Carlson et al. 2012*b*; Abood et al. 2014; Lee et al. 2014*a*; Busch et al. 2015), as discussed in the first section of this chapter. The sign of the oil palm productivity is positive and significant. The elasticity of forest cover loss to oil palm productivity is around 0.94, which is higher than to oil palm area. Improved oil palm productivity positively increases the losses of forest cover. In sum, increasing oil palm productivity and oil palm area will lead to a greater loss of forest cover.

Table 18. Oil palm productivity, oil palm area and forest cover loss (Robust standard errors: *** p<0.01, ** p<0.05, * p<0.1.)

VAR.	10% threshold	(se)	30% threshold	(se)
lnPOP	0.19484**	0.07209	0.19644**	0.07206
lnGRDPcap	0.46044***	0.09132	0.46014***	0.09129
lnPALMY	0.93998***	0.26081	0.94154***	0.26069
lnPALMA	0.4406***	0.0513	0.4398***	0.05128
d.Papua	-0.51729**	0.19567	-0.52012**	0.19558
d.Sulawesi	-0.38514*	0.1907	-0.38827*	0.19062
d.Sumatera	-0.85767***	0.11646	-0.85859***	0.11641
Year-effects	Yes		Yes	
Constant	-8.85995***	2.47767	-8.87583***	2.47661
Observations	218		218	
R-squared	0.7268		0.7270	
F-value	29.41***		29.44***	

It has been indicated that the main source of oil palm plantation is forested land. To reach the production target and/or to boost the local economy, oil palm expansion has been promoted. In 2008, the government allocated around 22.7 million ha of forestlands to be converted (Obidzinski et al. 2012). By 2010, the allocation for oil palm development on Sumatera and Kalimantan was approximately 11 million ha. Unfortunately, many have indicated that those allocated lands for oil plantation, in many cases, is still forested (Casson 2000; Fargione et al. 2008; Sheil et al. 2009; Stevenson et al. 2011; Carlson et al. 2012*a*). Koh and Wilcove (2008) estimates around 56 percent of oil palm plantation has been established on natural forest; while the World Bank estimates that some 70 percent of oil palm areas are cultivated on the previously state forest area (WB 2010). In Kalimantan case, similar occurrence has been reported (Curran 2004). However, a different estimation is claimed by the Indonesian Oil Palm Research Institute estimating that only 3 percent of oil palm plantations have been in primary forests (MoF 2008). In sum, the clearance of forests has been witnessed in the development of oil palm plantations in Indonesia. And, it is legal to do clear-cuts within the Conversion Forest Zones (Obidzinski et al. 2012).

To accommodate non forestry development (infrastructure, agriculture, mining and other land purposes), the government legally allocates the convertible forest. Even though conversion forests are supposed to insignificantly affect forest cover, scholars convince us that the convertible forest areas have been designated in primary forest (Irawan et al. 2013). The government has economic incentives to allocate forested land for oil palm development (Lee et al. 2014*b*) since the removal of timber during the land clearing phase for oil palm plantation generates one of the most important sources of tax revenue (Kartodihardjo and Supriono 2000; Irawan et al. 2013; Obidzinski et al. 2013). It does make sense to realize the fact that acquiring oil palm permit has been easier than obtaining forest permits (Stevenson et al. 2011). Nevertheless, low governance (such as illegal activities, poor law enforcement, contradiction between plan and implementation, and corruption) has exaggerated those issues (Hunt 2010; Stevenson et al. 2011; Brockhaus et al. 2012; Obidzinski et al. 2012).

For the company, establishing oil palm plantation in forested land is indeed favored (Lee et al. 2014*b*). Since the designated land is still forested, the clearance of trees has been a means for companies to accrue the windfall profits from conversion timber (Casson 2000; Casson et al. 2007; Schwarz 2010; Obidzinski et al. 2013). It is also the way of the holders to generate up-front capital for running their business. Opportunity cost calculation of oil palm supports this phenomenon (Irawan et al. 2013). Establishing oil palm in the previous state forest areas is preferable because it has more secured land tenure rights. By doing so, company can avoid disputes over land right conflicts (Lee et al. 2014*b*).

Unexpectedly, results on oil palm productivity are on the contrary with the common strategy adopted by the government and other international development institutions who implicitly argue that increasing oil palm yield could counteract environmental issues (deforestation) of oil palm plantation. Results are different with simulation analysis for Sumatera case (Lee et al. 2014*a*), as well as with one of a conclusion of global studies, suggesting that less cultivated area induced by an increasing of oil palm productivity can potentially save forest land (Evenson and Rosegrant 2003; Borlaug 2007; Koh 2007; Stevenson et al. 2011, 2013).

Based on these empirical results, this present study is able to confirm the Jevons` paradox in which oil palm productivity improvement induces a wider forest land consumed for oil palm plantation (the land consuming effects) that brings about more pressures on forest cover. In other word, Increase in oil palm productivity encourages business entities to expand their oil palm plantations, leading to the losses of forest cover; the land-consuming effect is observed. This present study argues that it is due to relatively high opportunity costs of oil palm plantation over other land-uses (Irawan et al. 2013) and its elastic demand (Fitzherbert et al. 2008; Stevenson et al. 2013). Higher productivity incentivizes business entities to expand their oil palm plantation, leading to more pressure on forests.

4.5. Concluding Remarks

Oil palm plantations have been criticized by their negative impacts on the environment, including deforestation. A big challenge for global community is how to make oil palm the key element of building future sustainable world (Barcelos et al. 2015). Besides the implementation of such sustainable practices, improving its productivity including intensification in existing production land is suggested by scholars (Miyake et al. 2012; Hoffmann et al. 2014) and adopted by international development cooperation agencies (WB 2011). Improving productivity has been also one of crucial policy taken by the government to meet the production target.

Unlike previous empirical studies that focus on area expansion, this present analysis investigated to what extent the improvement of oil palm productivity affects deforestation in Indonesia. Framed under the STIRPAT model, regression on panel data at the provincial level over the period 2000-2012 resulted in the positive association between oil palm productivity and forest cover loss that is mediated through oil palm area expansion. Hence, this study argues that the Jevons` paradox or the land-consuming effect is confirmed in the case of oil palm and deforestation in Indonesia. Consequently, the government should revise the current policy that promotes the improvement of oil palm productivity to save forests. Relatively high opportunity costs of oil palm plantation over other land uses (Irawan et al. 2013) and its elastic demand explains why this relationship occurs.

If halting deforestation is agreed to be a global commitment, results of this study provide an empirical evidence for the government and international agencies to reposition their current policies and strategies of promoting oil palm yield as a mitigation action of deforestation and climate change. Considering the fact that oil palm development has been expanded rapidly at the expenses of forests, the zoning policy by designating the development of oil palm plantation in unproductive and non-forested areas should be strongly taken into consideration (Koh and Ghazoul 2010; Meyfroidt and Lambin 2011; Wicke et al. 2011; Gingold et al. 2012; Newton et al. 2013). In this regard, high-yield oil palm technology should be directed towards how to make unproductive and non-forested areas socially, environmentally and economically feasible for oil palm plantation. However, serious environmental impact and further socio-economic feasibility assessment of utilizing those types of areas should be precautionary conducted (Miyake et al. 2012). Finally, it must be noted that this present finding should be put in the general context at national level.

Appendix

Table Annex 6. Collinearity diagnostics

Variable	VIF	Square VIF	Tolerance	R-squared	Eigen value	Index
lnDEF	1.93	1.39	0.5184	0.4816	6.7449	1.0000
lnGRDPcap	2.36	1.54	0.4242	0.5758	0.2399	5.3026
lnPOP	1.34	1.16	0.7447	0.2553	0.0064	32.5529
lnPALMY	1.34	1.16	0.7436	0.2564	0.0058	34.0713
lnPALMA	2.52	1.59	0.3970	0.6030	0.0016	64.7424
Mean	1.93				0.0002	184.3501

Condition Number: 184.3501
Eigenvalues & Cond Index computed from scaled raw sscp (with intercept)
Det(correlation matrix): 0.1493

Table Annex 7. Data summary

Variable	Observation	Mean	Standard deviation	Minimum	Maximum
DEF(30)	249	60195.85	76309.68	0	353590
DEF(10)	249	60396.65	76537.62	0	354423
GRDPcap	226	9244.88	6959.184	3152	33925.22
POP	249	3943287	2854301	554941	1.33e+07
PALMY	241	2993.53	635.2048	1650	4597
PALMA	241	354669.8	403308.3	466	2037733
lnDEF(30)	233	10.43292	1.14042	7.482682	12.77589
lnDEF(10)	233	10.43631	1.140453	7.486053	12.77825
lnGRDPcap	226	8.947573	.5565159	8.055793	10.43191
lnPOP	249	14.94369	.7136245	13.22662	16.40027
lnPALMY	241	7.980987	.2184214	7.408531	8.433159
lnPALMA	241	12.0302	1.4413	6.144186	14.52735

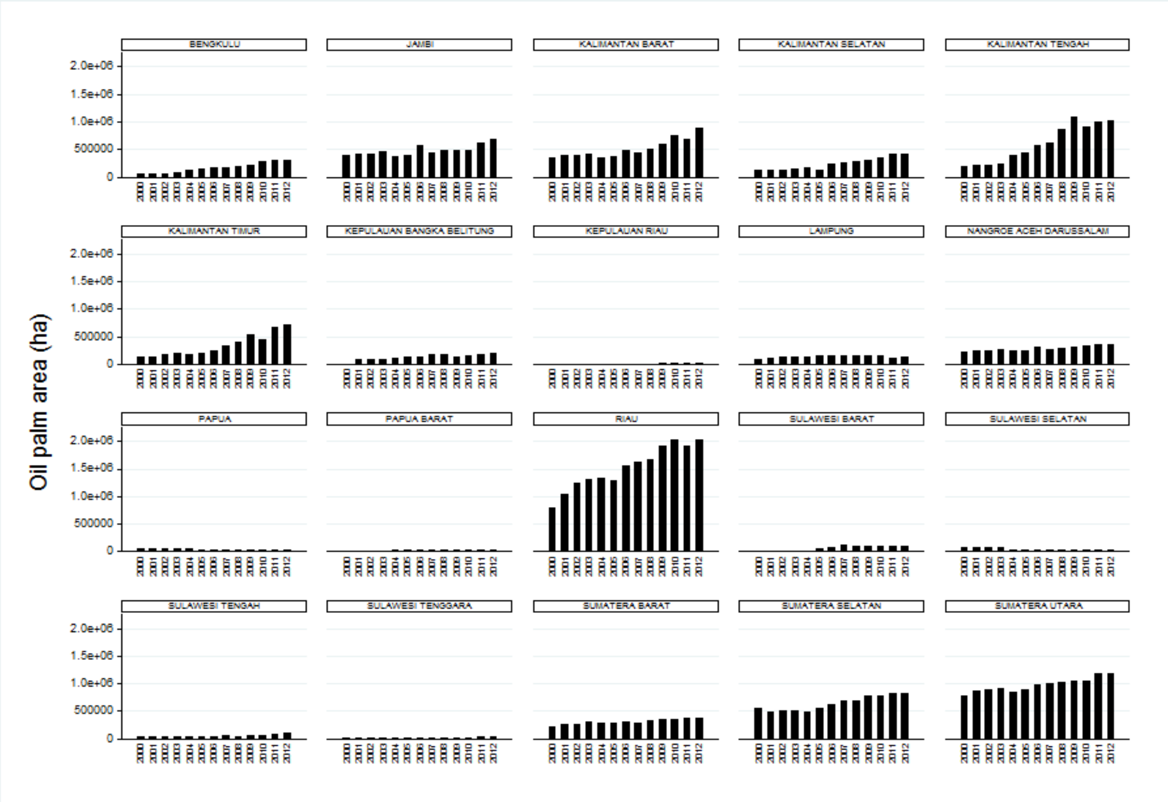


Figure Annex 4. Oil palm area by province in ha, 2000-2012 (Note: data in several provinces is not available; Source: MoA 2015)

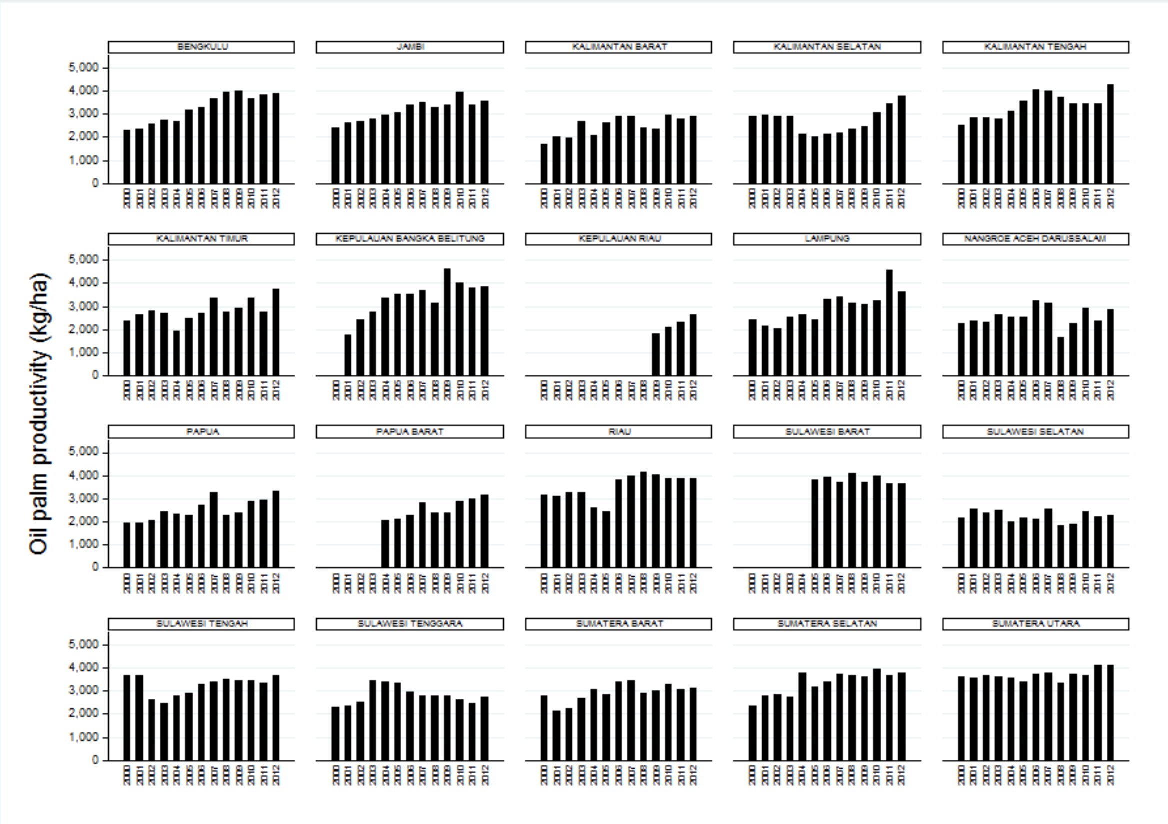


Figure Annex 5. Oil palm productivity by province in kg/hectares of crude palm oil, 2000-2012 (Note: data in several provinces is not available; Source: MoA 2015)

CHAPTER V. FINAL CONCLUSION

Deforestation is one of the greatest environmental crises (Ludeke et al. 1990), which is responsible for a significant part of GHG emissions (IPCC 2007; Vieilledent et al. 2013) and biodiversity loss (Gibson et al. 2011), and leads to further environmental crises, desertification (Geist 2005). In recent decades, deforestation has mostly occurred tropical developing countries, where their rate had been declining, but their trend has overturned (Budiharta et al. 2014). It will remain a major source of GHG emission for the foreseeable future (MEA 2005). Halting deforestation is a global political commitment and one of the main mitigation actions in climate change issues.

Indonesia is one of the largest tropical countries, contributing a very significant amount for global deforestation and GHG emission from land uses (Baccini et al. 2012). Amount and rate of deforestation in Indonesia is still relatively high; even currently, there is an increasing trend (Hansen et al. 2013*a*). With a serious global scrutiny, reducing deforestation in Indonesia can contribute to climate change mitigation at a globally and regionally significant scale (Busch et al. 2015).

Deforestation has been recognized an anthropogenic issue (IPCC 2007), within which various and dynamic proximate and underlying factors are interconnected (Angelsen and Kaimowitz 1999; Geist and Lambin 2002). Understanding those factors should be put in a certain context and circumstance, in order to improve our better understanding, as well as to bridge further discussion for policy examinations.

5.1. Final Conclusions

Deforestation and forest degradation have gained remarkable concerns as one of the greatest environmental crises. The losses of forest cover have contributed to biodiversity loss, GHG emissions and further environmental crises, desertification. The rate of tropical deforestation had been declining; however, this trend has overturned. Despites prominent policies and strategies have been established, deforestation in Indonesia also remains high, in terms of the amount of area and rate.

Most forest is state forest, managed under permit system. Their operations are criticized by their environmental impacts on forest cover. To estimate their impacts, this analysis incorporates two dominant forest permits (LP and PCP), for which the government policy is to discourage the former and to further promote the latter permits. Fixed-effect estimation finds that LP has no significant association with forest cover loss, while PCP leads to a greater forest cover loss. This finding is further confirmed by the second analysis in the third chapter of the thesis.

To counteract environmental issues, sustainable guidance and practices have been developed and promoted under forest permits. Among them, SFM certification has gained growing support and hopes to be a promising alternative non-state effort to mitigate deforestation under the permit system. Two types of SFM certification exist: the domestic (government-led) scheme and the voluntary (market-driven) scheme. However, roles of the latter scheme (represented by FSC-certified) to reduce deforestation in Indonesia are not generally confirmed in our initial analysis. It leads to another analysis to further explore to what extent the former scheme affect forest cover in Indonesia. Regression of the domestic SFM certification on forest cover loss at forest permit unit shows that mitigation action of the domestic SFM certification cannot be robustly confirmed, but partially observed.

Forest resources tend to be degraded under forest permits. Declining of forest cover, accompanied by relatively higher rents in other land uses, encourages forest land to be converted into other land uses, especially agriculture. Rapid agricultural expansion, especially oil palm plantation, has been indicated to have a strong pressure on forests. A common strategy adopted by the government and international development institutions is to improve productivity so that more agricultural land can be saved, turning into more forest land can be saved. Hence, the last analysis is to estimate impacts of oil palm expansion and to investigate to what extent agricultural technology improvement play a role to mitigate deforestation. By considering the fact that the effect of productivity improvement is mediated through area expansion, the Causal Mediation Analysis is employed within the STIRPAT framework. Unfortunately, results show that not only oil palm area positively affects deforestation, but also oil palm productivity improvement does. Hence, we argue that land-consuming effects or the Jevons` paradox work much stronger than land-saving effects in the case of oil palm productivity and forest cover loss in Indonesia. The effect of oil palm productivity is mediated through the expansion of oil palm area.

Analysis of this thesis covers factors of deforestation, especially forest permits, SFM and agricultural productivity. Based on results, finally, this thesis argues that reducing deforestation has to take into account other non-forestry factors that potentially bring about crucial effects on deforestation.

5.2. Policy Alternatives and Further Possible Researches

This last section is to summarize some policy alternatives in relation to deforestation mitigations, derived from empirical results. In relation to forest permits, ceasing new PCP could be a temporary effort to reduce deforestation. However, the most critical action is to urgently conduct a thorough evaluation of this permit in order to direct its extent towards reforestation and forest rehabilitation. Accordingly, in a general context, criteria of several forest-related terminologies should be revised in order to be consistent with a commitment to reduce deforestation. One example is that the current criterion of tree cover percentage of the unproductive forest area is too high. To be consistent with efforts of reducing deforestation, it is highly recommended that tree cover for the unproductive forest must be less than the maximum threshold of how a forest is defined (or maximum 30% tree cover in this case). When clarity of data and definition are clear and consistent, zoning policy in designating PCP for unproductive forest areas will not lead to deforestation.

Similarly, the development of oil palm should be strictly designated in unproductive and non-forested areas. In doing so, zoning approach is, again, strongly recommended to be imposed since land-consuming effects (the Jevon`s paradox) work stronger than land-saving effects (the Borlaug hypothesis). Additionally, the improvement of agricultural productivity should be directed towards unproductive and non-forested areas. In this sense, agricultural technology innovation needs to support this effort by making how unproductive and non-forested areas area socially, economically and environmentally feasible to be utilized for oil palm production.

Further possible studies are formulated as followings: (i) socio-economic-environmental feasibility study on the utilization of unproductive and non-forested areas for PCP and agricultural activities; (ii) comprehensive evaluation of current performance of PCP and the domestic SFM; and (iii) further research on how the possible positive environmental roles of LP can be enhanced and empirically implemented.

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