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Measuring Deforestation in Indonesia - A Comparison of Data and Methods

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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Affidavit

I, **BIRGIT VAN DUYVENBODE, BSC**, hereby declare

1. that I am the sole author of the present Master's Thesis, "MEASURING DEFORESTATION IN INDONESIA - A COMPARISON OF DATA AND METHODS", 71 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

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Abstract

Deforestation in Indonesia is a crisis of global dimensions. It has attracted worldwide attention in recent years, particularly due to forest fires leading to a transboundary haze crisis and the pressure of palm oil plantations causing the loss of habitat and biodiversity. While previous studies tend to focus on the drivers of deforestation, they fail to understand why there is no general consensus on the actual extent of deforestation in Indonesia. This thesis seeks to analyze the major data sources for the deforestation rate in Indonesia and to understand why their numbers differ from each other. Drawing on existing literature and expert interviews, the thesis analyzes five different sources in more detail: The Indonesian Ministry of Environment and Forestry (MoEF), the United Nations Food and Agriculture Organization (FAO), the Global Forest Watch (GFW) using the data from Hansen et al. (2013), Margono et al. (2014) and Gaveau et al. (2016). The findings indicate that there are four major factors causing the discrepancies in data: interests / purpose of existence of the respective source, definitions of forest area and changes, methodology, and other factors particularly concerning governance issues in the Indonesian context. The findings of this study suggest that particularly different interests have a strong influence on applied definitions and methodologies, and subsequently on the reported rates of forest loss. This thesis argues that due to different interests, which are often rooted in the purposes of existence and longstanding values of the institutions, discrepancies in data exist and will continue to persist in the future. Therefore, this thesis recommends that the interests of the reporting organization have to align with the interests for which the data are used in order to meet stated objectives. Furthermore, it provides a framework for potential fields of application of the data from the examined sources.

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List of abbreviations

Bappenas	Indonesian Ministry of National Development Planning
BPS	*Badan Pusat Statistik* (Statistics Indonesia)
CIFOR	Center for International Forestry Research
CO_2	Carbon dioxide
EO	Earth Observation
FAO	United Nations Food and Agriculture Organization
FRA	FAO Global Forest Resources Assessment
GDP	Gross Domestic Product
GFW	Global Forest Watch
GLAD	Global Land Analysis and Discovery
Gt	Gigatonne
ha	Hectare
IMF	International Monetary Fund
Mha	Million hectares
MoE	(former) Ministry of Environment of Indonesia
MoEF	Ministry of Environment and Forestry of Indonesia
MoF	(former) Ministry of Forestry of Indonesia
REDD+	Reducing Emissions from Deforestation and Forest Degradation, as well as conservation, sustainable management of forests and enhancement of forest carbon stocks
REL	Reference Emission Level
RPJMN	National Medium-Term Development Plan by *Bappenas*
RSPO	Roundtable on Sustainable Palm Oil
SDG	Sustainable Development Goal
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollars
Walhi	Indonesian Forum for the Environment

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1. Introduction

The problem of deforestation in Indonesia has attracted global attention in recent years. Forest fires in 2015 caused a transboundary haze crisis, which led to around 100.000 deaths (Koplitz et al., 2016) and made Indonesia the fourth largest carbon emitter worldwide (Harris et al., 2015). Deforestation threatens the habitats of many species which are endemic to the country's islands (Hance, 2016). In 2012, Indonesia was stated to have the highest deforestation rate in the world, even surpassing former deforestation champion Brazil, despite the Amazon being four times the size of Indonesia's forests (Margono et al., 2014). It is widely recognized that the underlying reasons for the immense forest loss in Indonesia are directly caused by expanding industries, including the palm oil, mining and forestry sector (Kissinger et al., 2012; Indrarto et al., 2012; Gaveau et al., 2016, etc.). However, the overall drivers of deforestation are complex, spanning from local, regional, national, and global, to social, political and economic dynamics (Kissinger et al., 2012).

While previous research has tended to explore the causes and effects of deforestation in Indonesia, studies have been confused by variations in the estimates of the actual extent of forest loss. The Ministry of Environment and Forestry of Indonesia (MoEF - Indonesian: *Kementerian Lingkungan Hidup dan Kehutanan, KLHK*), for instance, showed a decreasing trend in deforestation between 2000 and 2010 (Margono et al., 2012; Indrarto et al., 2012; CIFOR, 2012; Butler, 2012). In contrast, Hansen et al. (2013) measured a steady increase in the deforestation rate over the same period. The United Nations Food and Agriculture Organization (FAO) has likewise estimated different rates (see for example FAO, 2015). Despite the importance of data in research on forests, previous research has failed to acknowledge the underlying differences and reasons why the data vary so heavily. The fact that there is no scientific consensus on the actual extent of forest loss makes the inter-comparison between different scientific studies difficult and impedes an appropriate, evident-based discussion. Hence, the differences in the data need to be understood in order to explain and prevent ongoing deforestation in Indonesia.

The aim of this thesis is to analyze the main sources for the deforestation rate in Indonesia and understand why their numbers differ from each other. The research questions of this thesis are:

a. What was the annual deforestation rate in Indonesia during the last ten years?

b. How can the differences among deforestation rates in Indonesia be explained?

This thesis argues that the deforestation rate in Indonesia varies across various sources due to different definitions of forests and deforestation, methodologies and technologies of measurement, and other sources particularly concerning governance issues in Indonesia. Moreover, this thesis argues that these factors are strongly influenced by the interests and purposes of existence of the respective institutions. This thesis contributes to the current state of research in that it suggests a framework of application fields for the data from the reviewed sources. Therefore, it facilitates the understanding of differences in data and assists the choice of appropriate indicators for research and policy efforts.

The data in this report is drawn from expert interviews and relevant literature. They are neither comprehensive nor exhaustive. The thesis is divided into five sections: The first section gives an overview on forest loss in Indonesia and compiles different deforestation rates from different sources from 2000 until today. The second section presents the different definitions for forests and deforestation. Subsequently in section three, the methodologies and technologies of measurement for forest area and forest changes are reviewed. The fourth section analyzes the MoEF, FAO and Hansen[1] data sets in more detail, and elaborates on their definitions, methodologies, interests, advantages and weaknesses of data. It also shortly presents the studies of Margono et al. (2012) and Gaveau et al. (2016). The fifth section discusses the results, answers the research questions, and provides implications of the findings. Finally, the thesis closes with a conclusion and recommendations for future studies.

[1] Hansen et al. (2013) have developed the world's first global forest cover map based on satellite imagery. The 'Hansen map' constitutes the basis for a number of further studies on forest cover (e.g. Margono et al., 2014; Gaveau et al., 2016). It is used by the Global Forest Watch, a near real-time online forest monitoring platform.

2. Deforestation in Indonesia

Why do forests in Indonesia matter?

Indonesia's rainforests are some of the world's most ecologically valuable landscapes. More than half of the country's land area, consisting of somewhere between 13,466 and 17,508 islands (Bland, 2017; CIA, 2018), is covered with tropical rainforest. These forests are home to many endangered and endemic species and are an integral source of livelihood for a great number of people. It is estimated that between 6 and 20 million Indonesians are directly dependent on forests[2] (Sunderlin et al., 2000). Forests are vital for adequate water quality, soil stabilization and flood prevention, which is one of the reasons why Jakarta has been facing severe water problems recently (Hamzah, 2017). In the context of global warming, Indonesia's carbon-rich forests play a leading role in climate stabilization, storing about 24 Gt of carbon in living forest biomass (Saatchi et al., 2011). This corresponds to two thirds of total carbon emitted worldwide in 2014 (World Bank, 2018). Massive forest fires as part of a slash-and-burn agriculture in 2015 led to a severe haze crisis across much of Equatorial Asia causing around 100,000 deaths (Koplitz et al., 2016). Indonesia emitted more CO_2 from forest fires alone than the entire US economy in 2015, making Indonesia the fourth largest carbon emitter on the planet that year (Harris et al., 2015). The forest fires, however, are just one small part of a much bigger crisis: deforestation.

Why is deforestation a crisis?

Box 2.1: Terms

The term **'deforestation'** in this thesis refers to the long-term conversion of natural forest to another land use. It is used as a synonym for 'forest loss'. This includes, for instance, the conversion to agricultural fields, tree plantations, urban area, etc. However, there are many different understandings on deforestation.

'Tree cover loss' has to be distinguished from deforestation, in that it is based on tree canopy cover. Hence, tree cover loss does not only measure the loss of natural forest, but also includes the loss of other tree cover, such as plantations. Moreover, the measurement of tree cover loss is usually based on satellite images and does not consider whether the loss is permanent or temporary.

[2] Six million people are estimated to depend on swidden cultivation on the five main Islands of Indonesia (Sumatra, Kalimantan, Sulawesi, Irian Jaya, and the Moluccas), and 20 million people to live in or near forests (Sunderlin et al., 2000).

The severity of the consequences of large-scale deforestation is often underestimated. Deforestation in the tropics was called ‘one of the worst crises since we came out of our caves 10,000 years ago’ (Hance, 2016). This apparently extreme statement was not made without reason. Deforestation does not *only* cause the loss of biodiversity in flora and fauna, but contributes to global warming, soil erosion, landslides and floods, water surface runoff and polluted water, decreased precipitation and droughts, a loss of pollinators, and food scarcity, amongst others (Maxton-Lee, 2018; Margono et al., 2014; FAO, 2015). Simply put, deforestation brings the natural ecosystem out of balance. This can have severe implications for humans, too. It is believed that the effects of deforestation led to the extinction of the Maya people in ancient South America (Turner and Sabloff, 2012; Oglesby et al., 2010; Stromberg, 2012). Considering that the Maya civilization was an advanced civilization which was educated about environmental and water systems, one can only hope that our modern civilization has learned its lessons from history.

History of deforestation in Indonesia

Deforestation and forest degradation in Indonesia has a long history. After Indonesia's independence and the end of the colonial powers in 1945, the Indonesian Government was responsible for managing the country's natural resources for the first time. The first President, Sukarno (1945-1965), aimed to make the forestry sector a major source of development funds, with a target of USD 52.5 million (Indrarto et al., 2012). His government released a range of policies that gave the state the full authority to manage the country's forests and its resources and to establish state-owned companies. The state-owned forestry company (*Perhutani*), however, bore losses of approximately USD 10 million due to a lack of knowledge of the value of forest resources (ibid., 2012). A period of economic depression followed, and the political transition to a 'New Order'[3] under President Suharto (1966-1998) promised improvement in many ways (ibid., 2012). Economic development and the prosperity of the people were the new priorities (Indrarto et al., 2012). While policies were initially targeted at the forestry sector, the focus of economic development shifted towards the plywood industry in the 1980s and later to the pulp and paper industry in the 1990s (ibid., 2012). The Suharto era was marked by large-scale issuing of logging and plantation concessions, massive deforestation, monopolies, corruption and nepotism (ibid., 2012). For instance, Forestry Law 5/1967 issued concessions to large-scale industrial investors who had close ties to the military, the government, or the President (ibid., 2012). When Suharto stepped down in 1998, the

[3] The name given to the new regime to distinguish it from the previous, post-independence government.

country was in an economic crisis and sought financial help from international institutions such as the IMF and the World Bank (ibid., 2012). This allowed for the implementation of foreign forest management and conservation agendas, which actually caused a rise in deforestation (ibid., 2012). Moreover, the post-1998 (*reformasi*) era gave rise to decentralization and gave more power to local and regional governments to manage forests and issue permits for clearing (ibid., 2012; Saputra, 2018). This resulted in even higher rates of deforestation and paved the way for local leaders to sell forests illegally to plantation and mining firms for their personal benefit (Saputra, 2018). While under the centralized Suharto era, annual deforestation rates were between 0.55 and 1.7 Mha, under the new decentralized government, they were around 2.8 Mha per year between 1997 and 2000 (ibid., 2018). The FAO (2015) estimates that from 1990 to 2010, Indonesia lost 20.3% of its forest cover.

Economic development vs. deforestation

Indonesia's government and economy rely heavily on the industries that extract natural resources for their national development. Official 2014 data indicates that the export value of total production in the pulp and paper sector amounted to over USD 5.11 billion (FAO, 2016; Gaveau et al., 2016), compared to a GDP in the same year of around USD 890 billion (World Bank, 2018). The primary sector[4] generated almost 19% of GDP in 2014 (BPS, 2015; calculated by author, data downloaded on 24 May 2015). In 2013 / 2014, the palm oil plantations represented the largest plantation area by species in Indonesia, covering an area of 14 Mha (Gaveau et al., 2016). Around four million people in Indonesia are employed in the palm-oil sector, and another two million are estimated to work for the pulp and paper sector (Cramb and McCarthy, 2016). Consequently, the economic value of those industries frequently outweighs the ecological importance of forests. From 1990 to 2010, the land covered with palm oil plantations increased by more than 600% to a total land area of 7.8Mha in 2010, and during this period more than 90% of deforestation occurred in Sumatra and Kalimantan (Hansen et al., 2009). The continuing conversion to plantation land is not projected to stop, as only in Kalimantan for instance, palm oil licenses have already been granted but have not yet been activated for 90% of total remaining forest area (Carlson et al., 2013). Hence, the government's interests to support palm oil stand in conflict to forest conservation goals (McFarland et al., 2015).

[4] The primary sector relates to the extraction of raw materials. It comprises agriculture, livestock, forestry, fishery, mining and quarrying (BPS, 2015).

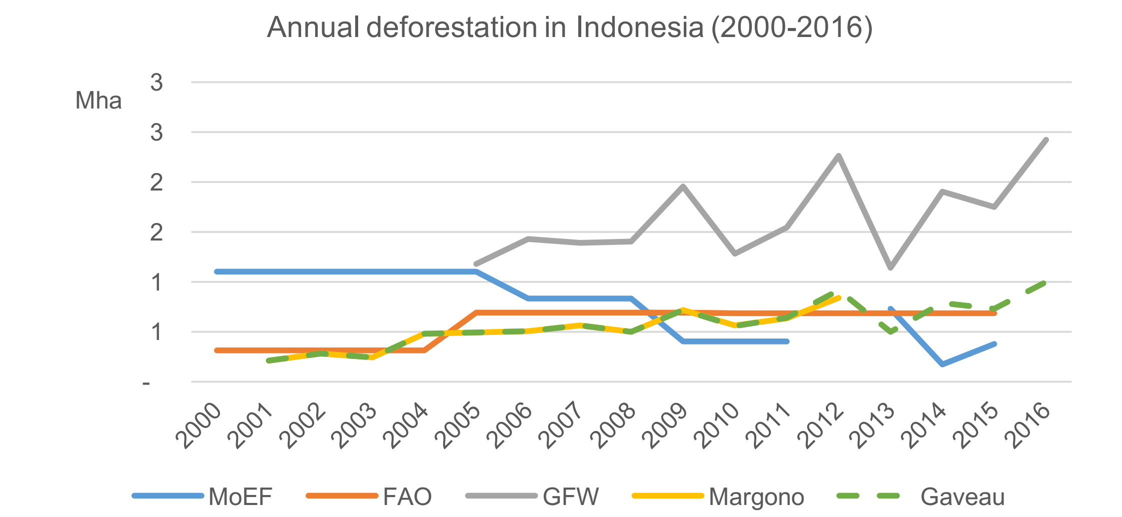
Conservation efforts have failed

Despite various conservation efforts, deforestation in Indonesia has not slowed down (Maxton-Lee, 2018; GFW, 2018). The Indonesian government has recently undertaken a number of efforts for the promotion of forest conservation such as the participation in the REDD+ program, the Norway-Indonesia bilateral partnership, and the Round Table on Sustainable Palm Oil (RSPO) (Maxton-Lee, 2018). None of those programs have been able to halt deforestation to date (ibid., 2018), even more seriously, some data show that the deforestation rate in Indonesia has accelerated during the initial phase of REDD+ in 2007 (Hansen et al., 2013; Margono et al., 2014). Reasons for this are complex. Maxton-Lee (2018) argues that forest conservation efforts have failed and will not be successful in the future due to the mistaken belief that the commodification of forests and natural resources will provide protection. Enrici and Hubacek (2016) explain the failure of conservation efforts and the acceleration of the deforestation rate with governance issues including corruption, a complex forest classification system, illegal logging, overlapping authorities and discrepancies in data across different levels of government. However, what confuses these studies and conservation efforts is the existence of contradicting data on the extent of annual forest loss in Indonesia (ibid, 2016; Hermoso, 2013; OECD, 2017; Maxton-Lee, 2018).

2.1. An overview of data on deforestation rates

There is more data on forests than ever before, but still there is no consensus on when, where, and how much forests are changing around the world (Harris et al., 2016). The headline of the 2015 FAO Global Forest Resource Assessment (FRA) proclaimed that ‘World deforestation slows down as more forests are better managed’ (FAO, 2015). For the same year, however, the Global Forest Watch (GFW) reported that ‘Global annual tree cover loss remains high’ (Petersen et al., 2015; Harris et al., 2016). Searching for the annual forest loss in Indonesia quickly reveals the complexity and opacity of this topic. Different sources report varying numbers for the total annual forest loss and, moreover leave a number of data gaps in the last decade. Some of the most important and most cited sources for the deforestation rate in Indonesia include the Ministry of Environment and Forestry (MoEF - Indonesian: *Kementerian Lingkungan Hidup dan Kehutanan,* KLHK), the Food and Agriculture Organization of the United Nations (FAO), and the Global Forest Watch (GFW) which uses the data set developed by Hansen et al. (2013). Additionally, there exist a number of studies building on the 'Hansen map', such as Margono et al. (2014) and Gaveau et al. (2016). Except for the latter two studies, all of those data sets show different results, sometimes with immense differences. Figure 2.1 shows the deforestation rates according to different sources.

Data is integral to the success of policies and conservation efforts (Hermoso, 2013). Accurate data is necessary to decide on the appropriate allocation of conservation resources (Wilson et al., 2006), and to implement and achieve stated priorities. The successful conservation of forests therefore is highly dependent on data and requires the information on how high the actual deforestation rate is. Existing data gaps can impede conservation efforts and policy goals. For instance, it was reported that for the Sustainable Development Goals (SDGs), which represent our modern world agenda, there is no data for two thirds of the 232 indicators; additionally, for 88 indicators there is neither an agreed methodology nor data for measuring them (OECD, 2017). A goal cannot be achieved if it cannot be measured (ibid., 2017).



Sources: MoEF (2014, 2015, 2016); FAO (2010, 2014, 2015), Hansen et al. (2013), GFW (2018), Margono et al. (2014), Gaveau et al. (2016), CIFOR (2012), Indrarto et al. (2012), Butler (2012).

Figure 2.1. Deforestation rates from different sources in Indonesia (2000-2016)

Figure 2.1 shows that the numbers for forest loss in Indonesia have varied heavily across different sources and that no common trend can be observed among them. The Ministry of Forestry (MoF)[5] reported a continually decreasing deforestation rate in the early 2000s, while Hansen et al. (2013) found that forest loss increased between 2000 and 2009. There is no consensus on a common trend, nor do studies agree on the extent to which deforestation occurs. For instance, the deforestation rate reported by the GFW in

[5] The MoF was merged with the Ministry of Environment (MoE) in 2014 to form the current MoEF (Jakarta Globe, 2014).

2014 was more than 10 times higher than the rate reported by the MoEF and almost 3 times the rate reported by the FAO (calculated by author, data derived from GFW, 2018; MoEF, 2015c; FAO, 2015). Figure 2.2 shows the extent of forest loss and forest area in 2010 reported by the different sources. The deforestation rate reported by the GFW (1.28 Mha) was more than three times the loss reported by the MoEF (0.4 Mha). The FAO (2015), Margono et al. (2014) and Gaveau et al. (2016) measured a loss of 0.68 Mha, 0.56 Mha, and 0.55 Mha respectively. The measured forest area varied from around 90 Mha reported by Margono et al. (2014) and Gaveau et al. (2016) up to 133.5 Mha by the MoEF (Indrarto et al., 2012).

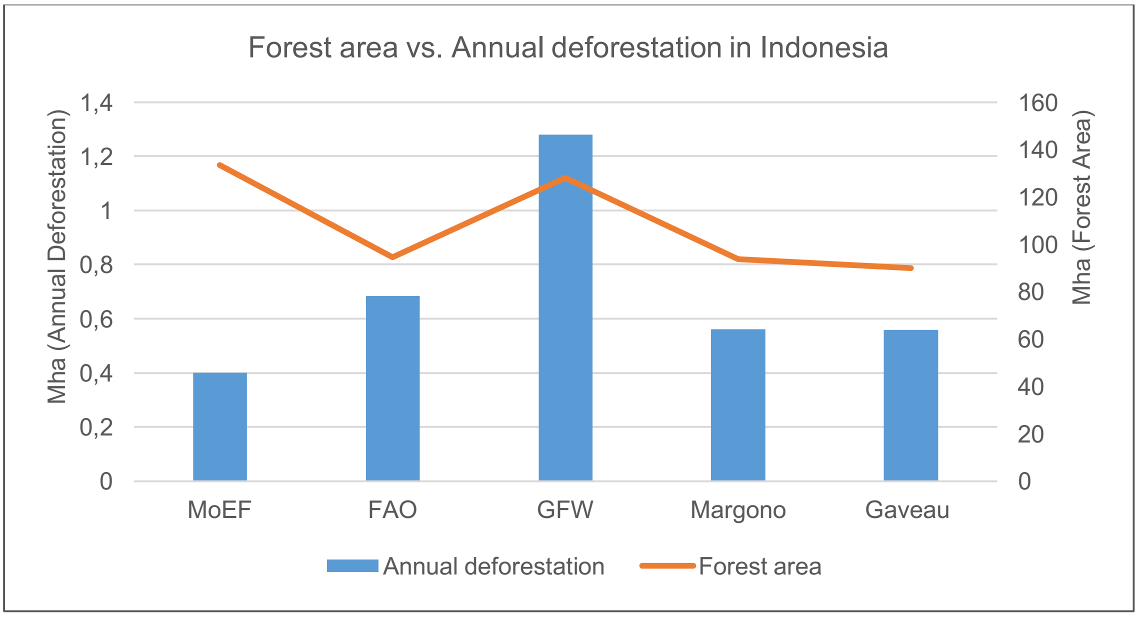


Figure 2.2. Forest area and the annual deforestation rate in Indonesia (2010) (Sources: see Figure 2.1)

Considering that the basic definition of deforestation is the conversion from forest land to non-forest land (Lund, 2018), it becomes clear that forest area constitutes the basis for the calculation of forest loss. Figure 2.2 shows that there is no common understanding of forests, as reported forest areas vary across the different sources. This leads to the expectation that the amount of forest area correlates with the amount of deforestation. However, the supposition that high forest area also leads to a high deforestation rate cannot be consistently observed across all reviewed sources. For instance, the data of the FAO (2015), the GFW (Hansen et al., 2013), Margono et al. (2014) and Gaveau et al. (2016)[6] seems to roughly follow this pattern. However, the numbers from the MoEF (Indrarto et al., 2012) are particularly significant in this regard. While the MoEF (ibid.,

[6] The figure for forest area by Gaveau et al. (2016) is an estimation by the author, which is based on available data and information. However, it was not validated by Gaveau et al. (2016).

2012) reported the highest forest area in 2010, it indicated the lowest deforestation rate compared to the other sources. Hence, there must be factors other than different understandings of forest area which influence the discrepancies.

Several scholars attempt to explain the differences in deforestation rates and forest area. Grainger (2008) and Keenan et al. (2015) point out that the underlying reason for discrepancies in deforestation rates is the use of different definitions, while Indrarto et al. (2014) point to varying forest classifications and data analysis methods. Chazdon et al. (2016) suggest that forest definitions vary due to different lenses through which forests are seen. Romijn et al. (2013) add that different forest definitions result in different estimates of forest area, which subsequently has an impact on the drivers of deforestation. Considering the influence of forest definitions, the next chapter reviews some definitions for forests and basic terminology of forest change.

3. Definitions

The concepts and definitions for forests determine how changes in forest cover are assessed and valued over time. In the following section, some basic terms for changes in forest cover are presented and different definitions for forests are reviewed.

3.1. Basic terms

Deforestation (forest loss)

Deforestation refers to the changing of forest land to non-forest land (Lund, 2018). This usually entails not only the logging of single trees, but it includes the loss of tree cover and/or the conversion of the forest area into another land use (ibid., 2018). Depending on the underlying forest definitions, some concepts of deforestation include the conversion of natural forests into artificial forests, such as plantations, while some do not (ibid., 2018; FAO, 2012).

Tree cover loss

Tree cover loss has to be distinguished from deforestation, as it is merely based on the loss of tree canopy cover (Hansen et a., 2013). It does not necessarily entail a conversion to non-forest land (ibid., 2013).

Forest degradation

Forest degradation differs from deforestation in that it does not include the complete loss of tree cover and/or the conversion of forests to another land use, but only some of the trees are removed or destroyed, e.g. logging of singular trees (Lund, 2018; FAO, 2012).

Reforestation (forest gain)

Reforestation, or forest gain, refers to the (natural or intentional) restocking of forest on previously deforested land (Lund, 2018; FAO, 2012). Reforestation cannot be seen as the 'mirror-image' of deforestation (Chazdon et al., 2016).

Tree cover gain

Tree cover gain is the gain of tree canopy cover (Hansen et al., 2013). It does not necessarily concern the gain of forest (ibid., 2013).

Afforestation

Afforestation refers to the establishment of a forest on land that historically was not forest land (Lund, 2018; FAO, 2012).

The basic concepts for deforestation are applied according to the understandings of forests by the individual stakeholders. For instance, the FAO (2015) defines deforestation as the 'conversion of forest to other land use', or the 'permanent reduction of tree canopy cover' below 10 percent. The MoEF (2016) defines deforestation as the conversion of officially-recognized forest land to non-official forest land (see also Indrarto et al., 2012). Other studies base their measurements on tree cover loss, such as Hansen et al. (2013). Margono et al. (2014) and Gaveau et al. (2016), on the other hand, define deforestation as primary forest cover loss and the loss of old-growth forests respectively. Kricher (1997), for instance, stated that tropical ecologists take biodiversity into account by defining deforestation as the cutting, clearing and removal of forest or related ecosystems and their conversion into less biodiverse land types, such as pasture, agricultural land, or plantations. Hence, the basic concepts for changes in forest cover are applied according to what constitutes a forest. However, there exists a myriad of understandings of forests, as they are viewed through different lenses (Chazdon et al., 2016).

3.2. Forests defined through different lenses

Definitions form the basis for any analytical research and provide the framework and boundaries of the studied matter. They determine the outcome and the interpretations that can be deducted from the results. Definitions can be found in dictionaries, for example, and seem to have a universal, objective approach. Objectivity is demonstrated by the ability of others to reproduce and verify one's definitions and results. The fact that there exist so many different definitions and outcomes concerning the development of forests leads to the supposition that definitions are subjective.

Forests have been defined in many ways, which reflects the diversity and complexity of forest systems and their understandings around the world. While the Cambridge English Dictionary (n.d.) defines a forest as '*a large area of land covered with trees and plants, usually larger than a wood, or the trees and plants themselves*', finding a common definition of forest is difficult. Currently, there exist around 1000 national definitions of forests worldwide (Lund, 2016), resulting from a diverse understanding of what a forest is due to a great variety of forest types in different regions across the globe. What is seen as a forest in Europe might not necessarily be considered a forest in Africa or Asia for instance (Venkateswarlu, n.d.). Hence, when talking about the terms forest and deforestation, it is always crucial to know the underlying definition used.

The existence of a variety of definitions of forests poses several challenges to a meaningful scientific and political discourse. Particularly in global climate change discourse, decision and policy-making is problematic if there is no agreement on the underlying definitions. The REDD+ program in Indonesia, for instance, requires the establishment of national forest reference emission levels (RELs) in order to monitor the impact of REDD+ activities (Romijn et al., 2013). According to a report by Romijn et al. (2013), the application of the FAO definition for the establishment of RELs would have resulted in a total area of deforestation of 4.9 Mha from 2000 to 2009, 18% higher than when using a 'natural forest definition', and 27% higher when using the national definition. In the light of such discrepancies, it is not without reason that forestry experts call for a unified definition of forests before defining the forests' future (Cerutti, Nasi and Sist, 2014). Forest definitions determine the legal, institutional, conceptual and operational basis for forest policies and conservation efforts (van Noordwijk and Minang, 2009). The absence of clear and appropriate concepts and definitions of forests are likely to impede current and future conservation efforts (van Noordwijk and Minang, 2009).

Chazdon et al. (2016) point out that there are many different lenses through which forests can be seen, which is the reason for varying definitions, assessments and evaluations of forests. For instance, forests can be viewed as a national dominion, a source for timber products, an ecosystem marked by trees connected with a wide variety of biological diversity, a home to indigenous people, a carbon sink, an agricultural or socio-ecological system, a source of ecosystem services, or all of the above (Chazdon et al., 2016). An overview on the different vantage points can be seen in Figure 3.1, taken from Chazdon et al. (2016). In this figure, the inner circle shows how a forest can be seen from different points of view, which determine the respective management objectives in the middle circle. The outer circle suggests institutions whose mission can be associated with the view points and management objectives provided in the inner and middle circles. This shows that forest definitions are created on a subjective basis, and finding consensus on one common definition is impeded by different interests of stakeholders from a variety of backgrounds. There are many different dimensions that define forests for different stakeholders, and no operational definition is able to embody all of these aspects (Chazdon et al., 2016).

While Chazdon et al. (2016) therefore argue that it is necessary to use tailored forest definitions according to the intended goal, in order to reach policy objectives, Putz and Romero (2014) found that one common definition for forest is needed in order to enable the preservation of ecosystem services and biodiversity. They suggest the ideal definition in tropical forests to refer to 'old-growth forests' which are pristine or naturally regenerated and older than silvicultural rotation ages (Putz and Romero, 2014; Cerutti, Nasi and Sist, 2014).

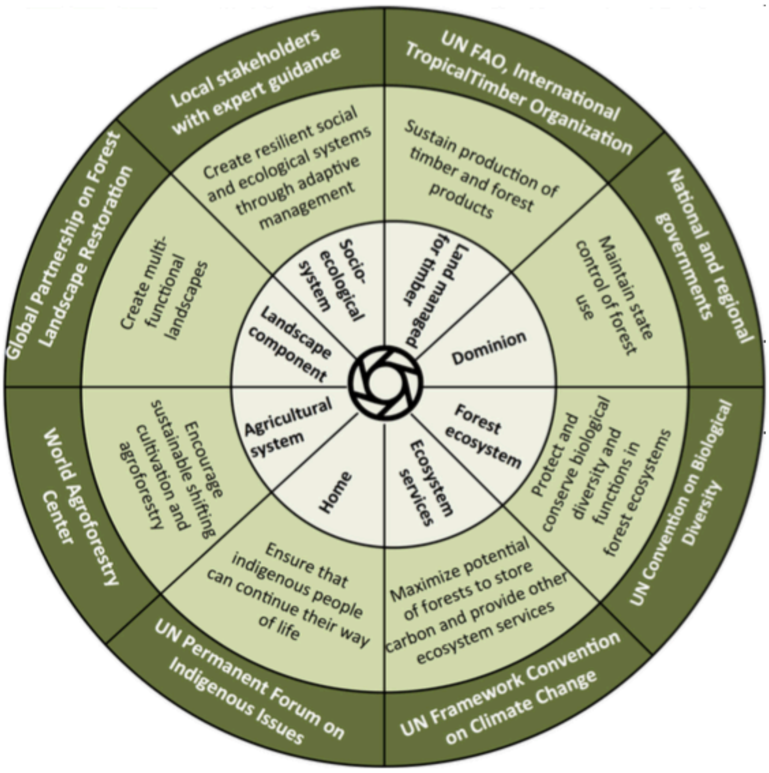


Figure 3.1. 'Different management objectives form the basis from which a forest is conceptualized and definitions are created.' (Chazdon et al., 2016)

3.3. What should be considered as forest?

Forests are complex systems that provide valuable ecosystem services. Such services include biodiversity, climate stabilization, soil stabilization, flood prevention and the maintenance of precipitation (Hance, 2016). Moreover, they are vital to human health and happiness (Li, 2018; USDA Forest Service, Pacific Northwest Research Station, 2010). The FAO (FRA, 2015) notes that specifically for Small Island Developing States,[7] forests are of outstanding importance concerning soil and water protection, as well as disaster prevention. Coastal and mangrove forests are of specific importance for marine habitats, fisheries and coastal erosion (FAO, 2015). The value of global forest ecosystem services was estimated at USD 4.7 billion (Constanza et al., 1997). While the value of these services is largely underestimated, a number of initiatives have evolved (e.g. the Natural Capital Project) aiming to integrate the value of ecosystem services into the policy-making process (Daily et al., 2009). Accordingly, ecosystem services should also be included in the formulation of forest definitions.

[7] Although Indonesia's islands are not officially part of the Small Island Developing States (SIDS), the importance of forests for Indonesia's islands is considered as equally high, independent from official designations.

4. Forest Monitoring

Forest Monitoring refers to the regular measurement of biological, physical and chemical parameters of forests in order to determine baselines to observe changes over time. Forests and their changes can be measured and monitored in a number of ways. Traditionally, forests were measured using national inventories, field surveys and aerial photography analysis. Since the rise of satellite technology, however, many of the measurements today are conducted or complemented by satellite imagery. They are especially effective if combined with other on-ground measurements.

Remote sensing in the spotlight

Remote sensing and Earth Observation (EO) started with aerial photography and progressed to the global, modern scale with the development of satellites in the second half of the 20th century (McCallum & Danylo, 2018). Lillesand, Kiefer and Chipman (2008) define remote sensing as ‘the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation’. It is used for a variety of purposes, such as assessing the damage caused by natural disasters, or predicting volcano eruptions (McCallum & Danylo, 2018). In principle, remote sensors gather information flows by measuring electromagnetic radiation that is reflected, emitted, absorbed and scattered by the Earth's surface and atmosphere. Therefore, satellites can capture not only visible light, but the whole electromagnetic spectrum, ranging from short gamma rays with a wave length of less than 0.0001nm up to radio waves with a wave length of several 100m. Specific technologies vary and may be active systems sending out and receiving electromagnetic energy, or passive ones (McCallum and Danylo, 2018).

Generic advantages of imaging from space include the fact that data can be provided as needed on all spatial scales, from global to national, regional and local, as well as on different temporal scales from daily to annually. With ongoing collection of data and some mission series dating back to the 1970s, data from EO is available over long periods of time and enables the depiction of long-term change and development. Moreover, satellite imagery enables the comparison of results among different countries which would otherwise lack standardization in measurements and methods. EO datasets can be used for the measurement of a wide array of different parameters and offer a unique and complementary information source with traditional statistical methods. Increasingly, these are freely and openly available, as for instance on Google Earth Engine (GEE)

(GEO, 2017) and they offer a relatively cheap way of monitoring large-scale environmental phenomena.

Disadvantages with EO data are, however, that humans perform the analyses, select the sensors and calibrate the data (United Nations Satellite Imagery and Geospatial Data Task Team, 2017). This allows for human errors in such analyses (ibid., 2017). Other challenges with satellite imagery include cloud cover, which can result in data gaps (ibid., 2017). Moreover, EO satellite datasets have a large size and complexity which requires high performance computing and cloud storage systems with high processing capabilities. The application of satellite data therefore needs the appropriate infrastructure and adequate knowledge. For monitoring purposes that need a high degree of detail and small-scale measurements, the acquisition of data can become relatively costly. It should also be noted that statistical indicators are not by default and have to be chosen carefully (GEO, 2017), which depends on factors that are not always objective.

Mapping forest cover extent and change typically requires optical data stemming from EO systems with a temporal resolution of approximately 5 to 10 years and a spatial resolution, depending on the exact purpose, ranging from a few meters to one kilometer (McCallum & Danylo, 2018). EO systems also need to have global and systematic acquisitions, and free, high quality images, as offered by Landsat. The Landsat program is a 'series of Earth-observing satellites' which are managed by NASA and the U.S. Geological Survey (U.S. Geological Survey, n.d.). It constitutes the longest continuous collection of land remote sensing imagery, from Landsat 1 up to Landsat 8 (ibid., n.d.). Landsat data are widely used in mapping forests, as they are available for a long time period, dating back to the 1970s, and can be applied to any geographical and environmental extent, at regional or national scale (GEO, 2017). Landsat 8 is the most recent Landsat satellite, which can capture a variety of bands with wave lengths from 0.43 μm up to 1.38 μm, covering visible light, such as green, blue and red, to invisible wave lengths, including short infrared wave lengths, with a spatial resolution of 30 meters. A prominent initiative that makes remote sensing data for forests freely accessible and easy to use and visualize, is Global Forest Watch, a dynamic online forest monitoring and alert system. In order to create forest cover maps, satellite imagery can be interpreted by automated methods or visual interpretations.

In order to improve the data collection and verification of remote sensing, satellite data needs to be coupled with additional information beyond forest cover. For instance, in conjunction with other data sources, as for example citizen science and Big Data. Big Data in general refers to a large volume of data which require high-speed computers for processing (Press, 2014). Citizen science, which is a process whereby non-scientists collect and report data on a volunteer basis, provides an accurate and relatively cheap means of obtaining detailed information on land cover (McCallum & Danylo, 2018). It is becoming increasingly important in the scientific field. Mapping and monitoring forests with the participation of local communities is of particular value, as people who rely on the forests for a living have deep knowledge of the forest resources (Vergara-Asenjo et al., 2015).

5. Data sources for the deforestation rate in Indonesia

The most important and cited sources for the deforestation rate in Indonesia include the MoEF, the FAO, and the Hansen deforestation data set. The following section elaborates on these sources and briefly presents two studies based on the Hansen data set: one by Margono et al. (2014) and the other by Gaveau et al. (2016). These sources will be reviewed in more detail according to their background and history, definitions for forest area and forest changes, methods of measurement, and interests.

5.1. Ministry of Environment and Forestry of Indonesia (MoEF)

Compared to other data, the MoEF tends to overestimate forest area, and underestimate forest loss. While Margono et al. (2014) reported a forest cover of 93.8 Mha for the year 2010, the MoEF measured an official forest land of 131.3 Mha in 2011 (FAO, 2015; Indrarto, 2012), even higher than the 128 Mha measured by Hansen (GFW, 2018; Hansen et al., 2013). At the same time, the deforestation rate in hectares per year is low compared to the other sources. In 2015, the MoEF reported a deforestation rate of approximately 0.38 Mha (MoEF, 2016), while the FAO (2015) and Hansen et al. (2013) reported a forest loss of 1.75 Mha and 1.87 Mha respectively (FAO, 2015; GFW, 2018). Gaveau et al. (2016) measured a forest loss of pristine old-growth forests of 0.73 Mha in 2015. The data of the MoEF show records in both directions.

5.1.1. Background

The Ministry of Environment and Forestry of Indonesia (MoEF) (Indonesian: *Kementerian Lingkungan Hidup dan Kehutanan, KLHK*) is the government ministry at the cabinet-level responsible for the management and conservation of the nation's forests. The current Minister of Environment and Forestry is Siti Nurbaya Bakar. Every year, the Ministry publishes the Environmental and Forestry Statistics (*Statistik Kemerintan Lingkungan Hidup dan Kehutanan*), which reports the annual data on forest area, deforestation, and environmental quality factors. The MoEF manages the total officially-recognized forest area of Indonesia, which currently amounts to an area of 126 Mha, which is about two thirds of the total land area (MoEF, 2016).

Why was the MoF founded?

After the end of the Dutch and Japanese colonials after World War II, the Indonesian national government assumed responsibility for managing Indonesia's natural resources. When Sukarno proclaimed independence in 1945, all natural resources became regulated by the state in order to enhance the welfare of the people (Contreras-Hermosilla and Fay, 2005). Both Sukarno and Suharto saw forests as a resource for timber, which was heavily exploited in order to meet economic as well as personal interests of politicians and related persons (Indrarto et al., 2012). For instance, the Suharto era was marked by large-scale logging and concessions for investors who had close ties to the President (ibid, 2012). In 1960, the Ministry of Forestry (MoF) was established as a response to the need for more coordinated forest governance. However, at that time the MoF had only limited management rights of forest land (Contreras-Hermosilla and Fay, 2005). With the 1999 Forestry Law, the MoF was given the full authority to manage and determine the Indonesian '*kawasan hutan'* (forest area). Due to the development of a culture of corruption particularly during the Suharto era, the MoF has often been called the country's most powerful and most corrupt state institution (Asia Sentinel, 2014). With the recent creation of other national agencies dealing with forests (e.g. the REDD desk), the power of the MoF has been decreasing and has to be shared with other institutions now (Wibowo and Giessen, 2014). However, the REDD desk was disbanded by President Jokowi in 2014 and its functions are now controlled by the MoEF (Widiaryanto, 2014). From 2010 to 2015, the MoF's policy priorities included the consolidation and stabilization of forest areas, reforestation and improvement of carrying capacity of watersheds, the control of forest fires, biodiversity conservation and the revitalization of forest utilization and industries (MoEF, 2016). It further focused on the improvement of local communities in or near forests, climate mitigation and adaptation of forestry sectors and the empowerment forest institutions (Purnomo et al., 2012).

Why was the MoE founded?

The term 'environment' and the awareness over environmental issues found its way to the Indonesian agenda much later than the interest in forestry resources. As a response to the Stockholm conference in 1972, the Government of Indonesia created the Office of the State Minister of the Environment, and the Environmental Impact Management Agency. These agencies became one Ministry in 2001, in order to obtain more power in the national decision-making process (MoE, n.d.). In 2010, the MoE announced its vision to be the realization of a reliable and proactive Ministry of Environment and achieving Indonesia's development based on sustainable development emphasizing the green economy (MoE, 2010). The mission is to make natural resource use sustainable through integrated environmental management policies, support sustainable development, foster partnerships, prevent and control environmental pollution, and boost internal capacity (MoE, 2010).

Merging the MoE and MoF

Under the new government of President Jokowi in 2014, the MoE and the MoF were merged into one common Ministry of Environment and Forestry (MoEF). Activists and other parties concerned about Indonesia's environment wanted the ministries to remain separate, as they were fearing for a clash of interests and the danger that the MoE might move to the exploitative 'bad' side of the MoF (Jakarta Globe, 2014). However, for many of the people working for the MoEF, it is very important that the 'E' stands before the 'F', which might suggest that they maintain their former ideal, but it also suggests that it could be difficult to integrate the two positions into one common Ministry (Interview partner A, *personal communication*, May 10, 2018). The executive director of the Indonesian forum for the Environment (Walhi), Abetnego Tarigan, noted that the MoF had two opposing roles with protecting the forests and giving out concessions for logging and plantation companies (Jakarta Globe, 2014). At the same time, the MoE's role was clearly to protect the environment and oversee the activities by the MoF (ibid., 2014). With the merger, the role of the Ministry has become more complex with clashing interests and overlapping authorities.

5.1.2. Definitions of forest, deforestation and forest classification

Official forest land ('kawasan hutan')

The MoEF defines forest, according to Forestry Law No. 41/1999 as 'an integrated ecosystem within a landscape containing biological resources, dominated by trees in harmony with its natural environment inseparable from one another' (Indrarto et al., 2012). It further states forest area as a ‘specific territory determined and/or decided by the government as a permanent forest’ (Purnomo et al., 2012; Indrarto et al., 2012; MoEF, 2016). According to the MoEF (2016), official forest land needs to be established in order to ensure legal certainty about the status of forest areas, the location of boundaries and the extent of a particular area designated as permanent forest area. Deforestation as defined by the MoEF is a change in land cover conditions from official forest land to non-forest land (MoEF, 2016). The definitions of forest and deforestation hence are a legal designations of official forest land area and the forest loss within those areas.

The forest classification system forms the basis for policies and regulations in Indonesian forest governance (Indrarto et al., 2012: MoEF, 2016). Based on Forestry Law No. 41/1999, forest areas are divided into conservation, protection and production forests:

- *Conservation forest*s are forest areas with certain characteristics, which have the main function of preserving the biodiversity of flora, fauna and their ecosystems. They consist of the sub-categories *Sanctuary Reserve Areas* (KSA) and Nature Conservation Areas (KPA). KSAs are areas with certain characteristics on land and in water and have the basic function of preserving diversity of flora and fauna and their ecosystem functioning as a living buffer system (MoEF, 2016, translated with Google Translate). KSA is further classified as *Nature Reserves* (CA) and *Wildlife Reserves* (SM). KPAs are areas with certain characteristics on land and in water, which have the main function of protection of life buffer system, preservation of diversity of plant and animal species, and sustainable use of biological natural resources and their ecosystems. It includes the sub-categories *Nature Conservation Areas* (KPA) such as *National Park* (TN), *Forest Park* (THR) and *Nature Tourism Park* (TWA) (MoEF, 2016, translated with Google Translate).
- *Protection forests* are forest areas that have the basic function of protecting life support systems to regulate water governance, prevent flooding, control erosion, prevent sea water intrusion, and maintain soil fertility.
- *Production forests* are official forest lands that have the main function of producing forest products. Production forests consist of *Permanent Production Forest* (HP), which are fully dedicated to the production of forest products, *Limited Production Forest* (HPT), where only part of the forest area is used for the production of forest products, and *Convertible Production Forest* (HPK), which is reserved for other land uses (MoEF, 2016; Indrarto et al., 2012). The MoEF (2016) also lists *Buru Park* (TB), a hunting resort, as part of production forests.

The above categories of forest area are furthermore classified into the overarching types of primary forest, secondary forest, and plantation forests. All other land which is not designated as officially-recognized forest land, is classified as land for other uses (APL), regardless of whether it has forest cover or not. An overview on legal forest designations, forest function, possible management practices, and area extent as of 2013 can be found in Table 5.1. This complex regulatory framework is often criticized for contributing to deforestation and forest degradation, for impeding institutional capacity, for providing increased opportunities for corruption, and for leading to the mismanagement of resources (Enrici & Hubacek, 2016; Indrarto et al., 2012; Contreras-Hermosilla and Fay, 2005).

Table 5.1. MoEF legal forest designation, use and area extent as of 2013

Forest type	Indonesian title	Forest code	Purpose / Function	Possible management practices	Area extent (Mha)	Forest loss by forest type for 2011/2012 (%)
Official forest	Kawasan hutan	-	Area under the authority of the MoF	Varies depending on sub-category (e.g. HL, HP, HTK)	~131	
Sanctuary Reserve Area and Nature Conservation Area	Kawasan Suaka Alam & Kawasan Pelestarian Alam	KSA & KPA	Preserving biodiversity of flora, fauna and their ecosystem	Forest preservation	~22	~5.9
Protection forest	Hutan lindung	HL	Protecting the water system to prevent flooding, control erosion, protect seawater intrusion and maintain soil fertility	Forest protection	~30.3	~7.3
Permanent production forest	Hutan produksi tetap	HP	Providing forest products	Selective logging, clear cutting	~28.8	~25.3
Limited production forest	Hutan produksi terbatas	HPT	Low intensity	Limited logging, very selective logging, very limited clear cutting, post-logging silvicultural treatments	~27.6	~10.7
Convertible production forest	Hutan produksi yang dapat dikonversi	HPK	Logging, agriculture estate, other uses	Clear cutting	~15.5	~8
Non forest land	Areal Penggunaan Lain	APL			~59.4	
Non forest land *with forest cover*	Areal Penggunaan Lain	APL			~8.17	~42.5

Source: Enrici & Hubacek (2016)

In 2016, 55% of Indonesia's forests were designated as production forest, 24% as protected forest, and 22% were designated as conservation forest (MoEF, 2016). The fact that the area for production forests exceeds the area of conservation and protection forests together shows that Indonesia's forests are mainly seen as a resource for forestry products. Forests therefore have been and continue to be an integral resource for

Indonesian economic development (Indrarto et al., 2012). This view is further reinforced by the fact that conservation and protection forests are actually not always conserved or protected. Although in theory conservation and protection forests are aimed at preserving ecosystems and their services, activities such as mining and logging can take place in these areas (Indrarto et al., 2012). This stems from the fact that the MoEF has the authority to issue lease-use permits for non-forestry activities even in conservation and protection forests (ibid., 2012).

Official versus non-officially recognized forest area

The definitions of forest and the deforestation rate of the MoEF are legal designations and do not necessarily depict the actual situation. Official forest land is not necessarily covered by forest, and not all forest is designated as official forest land (Enrici and Hubacek, 2016). In principle, even grassland could be declared as '*kawasan hutan'* or actual forest areas could be excluded (ibid., 2016). This has resulted in a dichotomy between non-forested land that can be recognized as official forest area, and forest land that is not officially recognized and therefore is not considered forest (Enrici & Hubacek, 2016). Therefore, not all deforestation that actually happens is included in official deforestation rates by the MoEF (ibid., 2016; Margono et al., 2012). Since the introduction of REDD+, many official forest areas have been converted to non-officially recognized forests, which have been found to be particularly vulnerable to deforestation (Enrici & Hubacek, 2016; Margono et al., 2012). In 2011 / 2012, 42.5% of the over 8 Mha non-officially designated forest land (APL) with primary forest cover were cut down (Margono et al., 2014). This area amounts to the size of almost half of Austria, which was cut down during one year without being considered in the official deforestation rate. The existence of non-officially recognized forest land complicates accountability, transparency, and reporting. It is one of the major reasons why the data from the MoEF, as well as from the former MoF, differ from those by other sources.

5.1.3. Measurement

'Net' versus 'gross' deforestation

A difference has to be made between the 'gross' and the 'net' approach of reporting deforestation. Gross deforestation counts the total forest area which has been deforested. Net deforestation, however, deducts reforestation and afforestation from these figures. Hence, the reported deforestation rate can be negative, if a net approach has been applied. For instance, the MoEF's reported figures for the deforestation rate follow a 'net' approach (for example MoEF, 2016).

The MoEF reports net deforestation, where afforestation is deducted from the deforestation rate (Interview partner A, personal communication, May 10, 2018). Hence, in the MoEF reports, the deforestation rates for certain regions and forest classes are frequently negative. In 2015, for instance, the reported deforestation rate for plantation forest amounted to minus 25,000 ha, as new plantation forests were established (MoEF, 2016). However, Chazdon et al. (2016) argue that forest loss and forest gain cannot be seen as two opposite 'mirror-images'. Forest loss is in most cases geographically concentrated and happens in a short period of time, which is the reason why it can be rather easily documented and tracked (Chazdon et al., 2016). On the other hand, forest gain is not so easily detectable, but is mostly more fragmented and does not produce a forest with the same ecosystem services[8] as the original forest. Hence, the addition and amalgamation of deforestation, reforestation and afforestation produce a misleading picture of the actual situation of forest change dynamics.

Visual interpretation of Landsat imagery

The estimation of forest cover and changes by the MoEF are based on the visual interpretation of Landsat optical remote sensing imagery (MoEF, 2016). From this manual interpretation the MoEF creates land cover maps on which the data on forest area and changes are based. The visual interpretation has to be distinguished from the automatic and semi-automatic interpretations of satellite imagery (Interview partner A, personal communication, May 10, 2018). While visual interpretations are manually conducted by humans, automatic interpretation is conducted by computers (Sivakumar, 2010). Semi-automated methods combine both (ibid., 2010). All interpretation approaches have advantages and disadvantages. For instance, automated methods are cost-effective for large geographic areas, provide consistent results, and are compatible with other digital data (ibid., 2010). However, the accuracy of their results is often difficult to evaluate (ibid., 2010). Visual interpretations are simple and subjective, however, they are expensive for large areas, require a lot of time and can include human errors (ibid., 2010). Different interpretation methods of satellite imagery can lead to different results in land cover and changes (Interview partner A, personal communication, May 10, 2018).

The MoEF classifies forest area into seven classes based on forest use types and identifies in total 23 land cover classes. However, there is doubt that the MoEF can actually identify that many types of forests on satellite imagery, as this exceeds the

[8] Ecosystem services are the goods (e.g. food) and services (e.g. waste assimilation) that directly or indirectly benefit and sustain human populations (Constanza et al., 1997). Their economic value is often underestimated (ibid., 1997).

capability of the technology (Interview partner A, personal communication, May 10, 2018). While the overall forest cover baseline maps produced by the MoEF are not significantly different compared to other automated methods using satellite-imagery, changes are often not reported as they can be observed by other scientists (Interview partner A, personal communication, May 10, 2018). The reason for this cannot be identified, as the MoEF is not very responsive to answering questions.

5.1.4. Interests / Purpose

The interests in the MoEF are complex and difficult to clarify. However, general interests and views on forests include forests as a national domain, as an ecosystem that has to be managed sustainably and measured accordingly, economic interests, clashing interests resulting from the merger of the MoF with MoE, and personal interests of politicians at different governmental levels.

Forests as a national domain

National governments see forests as a dominion, and it is their goal to maintain state control of forest use (Chazdon et al., 2014). Defining forest as a national 'officially-recognized' domain implies a number of political interests that the MoEF pursues as part of the Indonesian government. First, national governments want to maintain control over their territory (Chazdon et al., 2016). Eilenberg (2014) found that the discourse on national security and sovereignty intensified the agrarian development of the Indonesian-Malaysian border. The interest to maintain control over state territory can therefore stand in opposition to forest conservation efforts. Forest defined as a national domain, however, further implies that the government does not necessarily have to justify itself for its land use data published. Provided the MoEF complies with national regulations, in principle it can officially recognize or not officially recognize forest land as it wants because it has the full authority to do so. Subsequently, there is no strong or consistent interest in justifying data and making additional data available to the public. In this context, Greenpeace took the MoEF to court in 2017 because it would not release the baseline data to the geospatial land use maps published only in PDF and JPEG formats. The MoEF won the case and was therefore not legally required to publish the data (Jacobson, 2017).

Ecosystem and sustainability interests

The mission of the MoEF is to organize the formulation and implementation of forestry and environmental policies in a sustainable manner (MoEF, 2014). The MoEF Strategic

Plan 2015-2019 relates the National Medium-Term Development Plan (RPJMN) by Bappenas (Indonesian Ministry of National Development Planning) to the MoEF level (Indrarto et al., 2012; MoEF, 2015c). It states that the MoEF intends to ensure that the environment is in balance with the needs for human life, and that natural resources are able to contribute to the national economy (MoEF, 2015b). As the people working in the forestry department of the MoEF are not just politicians but also forestry experts like others, they are interested in the preservation and measurement of actual forests rather than other land types (Interview partner A, personal communication, May 10, 2018). However, it should be noted that they are also part of a big construct of regulations and overlapping authorities on different government levels, which lead to the pursuit of different and even conflicting interests within the ministry.

A clash of interests - MoE versus MoF

The MoEF is not a coherent construct pursuing one single set of interests. In addition to the country-wide decentralization, the merger of the MoF and the MoE might have led to a clash of interest pursued within the ministry. With the MoF's dual role of conserving Indonesia's forests and issuing logging and plantation permits, and the MoE's mission to protect the environment and oversee the activities of the MoF, conflicting interests within are pre-programmed (Jakarta Globe, 2014). Disagreement in data of the MoE and the MoF have not only occurred before the merger (Enrici & Hubacek, 2016), but also afterwards. For instance, the 2015 Forest Reference Emission Level (FREL) report to the UNFCCC contradicted the previously published MoEF statistical report (MoEF, 2015a; MoEF, 2015c; Greenpeace Indonesia, 2015). The recent performance of the MoEF and the impact of its policies on Indonesia's forests is subject to future studies and exceeds the scope of this thesis.

Conflicting interests due to decentralization

The interests of the MoEF cannot be seen from a top-down approach only. Different government institutions, private institutions, NGOs, and multilateral institutions which are affected by decentralization too, frequently have conflicting agendas (Cohen et al., 2006). Decentralization has resulted in overlapping and a relatively equal legal authority of the national and local governments over land-use and allocation, therefore, local governments' interests are an integral part of actual forest governance and its implementation. Setiawan et al. (2016) argue that the overlapping authorities made it possible that local governments issued plantation permits covering over 4Mha of forest land to investors without showing them to the MoEF for a formal release. In the competition for budget, political authority and legal mandates, it is logical that local governments take advantage of decentralization policies and use them to their own advantage according to their personal interests. In Kalimantan, local politicians often see forest land as a resource that brings them capital for the elections by issuing licenses (Setiawan et al., 2016). A strong correlation was recorded between 2001 and 2008 between deforestation rates and local elections in Indonesia (Burgess at al., 2012).

Conflicting data within the government

Decentralization led to conflicting data across different levels of government. In 2012, for instance, the MoE has reported a forest cover of roughly 60 Mha in Papua, while the MoF measured a rate of 44.2 Mha (Enrici & Hubacek, 2016). It seems that, although the MoEF is one unified ministry now, it is nevertheless not certain or consistent about its own numbers. In September 2015 the MoEF (2015a) announced its official Forest Reference Emission Level (FREL) report to the UNFCCC. It constitutes an integral part for the REDD+ reporting, establishing baseline levels for deforestation and emissions. Greenpeace Indonesia (2015) analyzed this report before publication and concluded that there were three major issues with the data in it: data revision, data omission, and calculation errors. The report was based on revised land cover maps which differ from those just previously published in the MoEF's statistical report and the baseline data were not available. Moreover, Greenpeace identified data gaps, e.g. that the forest loss resulting from forest fires were not included in the FREL calculations. Additionally, there were mistakes in the mathematical calculations of the baseline deforestation rates.

The conflicting data across different levels of government motivated the One Map Initiative, which since 2014 has made efforts to bring together land use, land tenure and other spatial data into one single national database on which all national land-use decisions should be made (Maxton-Lee, 2018). Until now, different levels of government (District, Provincial and National) have worked with different maps frequently showing conflicting information, as well as private sector data having different alignments (Spatial Informatics Group, 2016). Technological and infrastructural gaps also play a role in this initiative, as regional and provincial offices sometimes even work with paper maps which are not yet available in a digital format (Maxton-Lee, 2018). Consequently, the One Map project is very ambitious and complex, and it is very sensitive at all levels of government and society, touching on land ownership, land tenure and land rights (Spatial Informatics Group, 2016). The process and efforts to produce the common map are not yet finished and are still going on.

Transparency and culture of secrecy

The MoEF has a culture of secrecy, especially with foreigners, and is very protective of their data (Interview partner A, personal communication, May 10, 2018). According to interview partner A, this is the reason why the MoEF is not very popular with foreign researchers and their data is rather avoided. In the course of the research for this report, the MoEF was likewise unapproachable and not willing to contribute any information.

Economic interests in central government

In addition to the interests pursued within the MoEF, there are also other governmental priorities that must be considered. Since Indonesia's independence 73 years ago, it has always been the 'welfare of the people', meaning economic growth and income, that has been prioritized by leaders. However, this term is open to interpretation. Still in 2018, Indonesia is setting economic growth as its priority goal, for instance, in order to reduce poverty to less than 10% (The Jakarta Post, 4 January 2018). Palm oil and its sub-sectors are some of the major sectors that have been supported in central government agencies' regulations (Setiawan et al., 2016). The central government even made it clear that palm oil plantations needed to be safeguarded from the negative environmental campaigns against them (ibid., 2016). Considering the wide variety of interests standing in opposition to conservation efforts, it seems that the intentions to halt deforestation in Indonesia are outweighed by a set of other complex interests and the general notion of economic advancement.

5.2. FAO

5.2.1. Background

FAO forest definitions and data are the most frequently used today (Grainger, 2008). The FAO was founded after the Second World War in 1945, as a response to food scarcity and hunger. Counting more than 194 member states, the FAO operates in over 130 countries worldwide. Next to food security, the FAO is active in a number of other related fields, including agriculture, forestry and fishery. In this context, the organization aims to make agriculture, forestry and fisheries more productive and sustainable. It serves as a source of information, and a provider of technical assistance to the development and implementation of national programs. The FAO emblem shows its motto *Fiat panis*, meaning 'Let there be bread' (see Figure 5.1). Concern about shortages in forest products motivated the publication of the world's first report on global forestry inventories (Holmgren and Persson, 2002). Since 1946, the FAO has published its Global Forest Resource Assessments every five to ten years. With more than 100 ecological and socio-economic variables reported, the assessment aims to provide a comprehensive and integral evaluation on the state of the world's forests and how they are changing. The report is based on data reported from 234 countries and territories. The forest definitions and data from the FRA inform the decisions made by a variety of institutions, including the FAO itself, the UNFCCC, REDD+, the UNCBD, the UNCCD, and the UN Forum on Forests (Keenan et al., 2015).

Figure 5.1. The FAO logo

5.2.2. Definitions

In 1948, the FAO developed a definition for forests which would allow for the assessment of wood harvesting potential. It was the first forest definition which was used by all member countries (Grainger, 2008). The 2015 Global Forest Resources Assessment (FRA) defines forest as land spanning more than 0.5 ha with a canopy cover of more than 10% and trees higher than 5 meters, or trees able to reach these thresholds *in situ* (FAO, 2015). The explanatory notes explain that forest is determined by the absence of 'other predominant land uses', but it also includes areas that are 'temporarily unstocked due to clear-cutting as part of a forest management practice or natural disasters, and which are expected to be regenerated within 5 years' or longer if the local situation allows

(FAO, 2015). Forests also include mangrove forests, no matter if on land or in water. Rubber wood, cork oak and Christmas tree plantations count as forest. Palm and bamboo plantations are considered as forest, if the canopy cover and height requirements are met. Hence, the FAO (2015) includes in their definition for forest natural forest, clear-cut forest, rubber plantations, tree seedlings and young tree stands, amongst others. On the other hand, agricultural production systems not constituting a timber resource are not included as the crops are grown under tree cover, such as agroforestry, oil palm plantations, olive orchards, and fruit tree plantations (ibid., 2015). Land that has only 5-10% of tree cover is classified as other wooded land. All other land that is not forest or other wooded land is called other land.

Deforestation refers to the conversion of forest into another land use, or the 'permanent reduction of the tree canopy cover below the minimum 10 percent threshold' (FAO, 2014). Moreover, the conversion into another land use has to be on the long-term or permanent basis (FAO, 2012). Deforestation includes for instance the conversion from forest to land for agricultural use, pastures, water reservoirs, or urban area. It does however not consider forest that is cut down under the 10% threshold and which is expected to regrow naturally or with the aid of silvicultural measures (FAO, 2012). Similar to the MoEF, the FAO reports net deforestation taking into account forest gain and afforestation.

5.2.3. Measurement

The FAO relies on data of national governments which are self-reported by countries and can be collected through a variety of measurement methods, including remote sensing, forest inventories and extrapolation from past data, academic studies, special studies, government registries or district forest offices (Harris et al., 2016; MacDicken, 2015). There are various disadvantages with this method. The way in which data is collected has changed over time. While the methods and definitions of the numbers reported to the FAO were initially very different, they have been harmonized gradually. Since 2005, most of the data has been collected through National Correspondents (NCs), who submit the data on behalf of the respective governments instead of the governments themselves. Additionally, since FRA 2015, the FAO has started a capacity building strategy providing the NCs with guidance and technical assistance in order to improve consistency and comparability of reported data, to promote remote sensing techniques in the national data alleviation and strengthen national networks and awareness for FRA reporting (FAO, 2016).

The FRA data is collected through the FAO Collaborative Forest Resources Questionnaire (CFRQ) which is filled out and submitted by the NCs through the Forest Resources Information Management System (FRIMS). At the beginning of 2013, the CFRQ questionnaires were sent to the NCs and they had 10 months to fill out the standardized tables in the FRIMS (FAO, 2016). In order to facilitate the reporting process, the tables were pre-filled with the data from previous FRAs. The FRA has been criticized for its methodology of collecting data, because it faces several weaknesses, such as incomplete or inaccurate reporting. While the FAO provides guidance on how and what to report, many countries still often use their own definitions and methods (Harris et al., 2016; MacDicken, 2015).

5.2.4. Interests and purposes

The FAO defines some of its major goals as being to eliminate hunger and make agriculture, forestry and fisheries more productive and sustainable. One of the major goals of the FAO is the sustainable management of forests worldwide. The fact that forestry is stated together with agriculture and fisheries suggests that all of the three sectors have the purpose to feed the world. In fact, the foundations of the FAO are built on the need for food security and the secure supply of other resources. Just by looking at the name 'Forest Resources Assessment', it becomes clear that in the eyes of the FAO, forests are seen as a resource for timber supply rather than an ecosystem or a conservation area. As Chazdon et al. (2016) pointed out, the FAO views forests as land managed for timber, and its primary management objective is to sustain production of timber and forest products. This view explains why plantations and other production forests are considered forests in the FAO definition.

5.2.5. Discussion

Definitions

The FAO data published in the FRA are widely criticized, and their biases and limitations are much discussed in the literature (Grainger, 2008; Harris et al., 2012; Jones, 2017; MacDicken, 2015; Hansen et al., 2013). Limitations include the definition of 'forests' which is based on land use and not actual land cover, forest area and changes are reported as net values only, inconsistent methods between countries, and the fact that forest definitions and methods have changed over time.

The definition of forests, which includes non-palm oil tree plantations in its definition of forest cover, is widely criticized for being too inclusive (Jones, 2017). This is the reason why on International Forest Day on 21st March 2017, more than 200 organizations submitted a signed open letter to the FAO asking them to change their definition of forests (ibid., 2017). In this definition, an area of plantation is merely the same worth as the identical amount of area covered with tropical rainforest. Plantations do not provide the same ecosystem services (e.g. biodiversity, pollination, soil fertility and water quality) as forests do, hence, they should not be included in the definition (Gaveau et al., 2016). Furthermore, even clear-cut plantations which are 'temporarily unstocked' count as forest, although there is not one single tree present. Subsequently, the numbers for the deforestation rate are biased. For instance, the replacement of natural forest with non-palm oil tree plantations does not count as deforestation, but it is reported as 'net-neutral'. This suggests that plantations and forests are just of the same value and it does not count as deforestation if forests are replaced by plantations. This approach leads to misleading results of forest cover and forest loss. The FAO regards forest as a resource for timber, regardless of the environmental services a forest normally delivers. However, the FAO argues that their definition is a product of 'bottom-up harmonization' of definitions and thorough consultation with national governments and major stakeholders (Jones, 2017). The current definition for forests is well-established and has been used since the year 2000, therefore it is improbable that the FAO will change it in the near future, according to some scientists (ibid., 2017).

Methodology / Technology

The way in which data is collected and is dependent on national reporting is widely criticized. One point of criticism concerns inconsistent methods between countries. The FAO definitions are common guidelines for the FRA reporting, pointing out that forests should have a certain area, tree height, and potential tree cover. However, each country is free to define their own thresholds within these criteria (Lake and Baer, 2015). This results in the inability to compare the data between different countries. MacDicken (2015) points out that the major challenges with the FRA data include incomplete or inaccurate country reporting, the difficulty to control data, numbers not adding up, and reported that data was not spatially explicit. Grainger (2008) notes that due to inconsistencies and changes in methods and definitions over time, no long-term trend for the deforestation rate can be made using FAO data. Even the FAO (2015) itself points out that comparisons of FRAs from different years cannot be readily made. MacDicken (2015) argues that with constant new developments in technologies and remote sensing, it is likely that variables will change from one FRA to the next. While the FAO is indeed interested in moving towards remote sensing to make their data more consistent and accurate (FAO, 2016), the application of satellite imagery according to their forest definitions can be difficult. As natural forests and tree plantations look similar on satellite pictures, the harvest of trees in plantations would equally result in documented tree loss, which is actually not considered as deforestation by the FAO (Jones, 2017).

Another major issue is that data reported to the FAO are often not up to date. In the 2015 FRA, forest area figures of 87 countries were at least 10 years old (Harris et al., 2016). When country reports are not available, the FAO uses available literature and expert estimates to fill the gaps. Developed countries on the Northern hemisphere tend to update their data more frequently than developing tropical countries. This creates a reporting disparity between different types of forests in different zones, resulting in a disadvantage in data for tropical forests, where most of the deforestation in happening (Harris et al., 2016).

Interests

One of the major goals of the FAO is the sustainable management of forests. Sustainable 'management' already implies that forests need to be 'managed' in order to extract some resource for money. However, the question is who will benefit from the resource extraction and whose interests will be particularly pursued? The answer is revealing: more than 60% of FAO funds come from voluntary donors (FAO, 2013). In the competition for financing, the FAO puts a focus on the private sector, which is an important source for funding (ibid., 2013). As participation in ODA requires a lot of effort and is expensive in money and time, there must be some reason for an actor to participate in ODA (Harvey and Wood, 1996). Therefore, the participation is suspected to be subject to some marginal benefit analysis (ibid., 1996). Possible fields of interest to donors could include for instance the choice of tree species, intercropping on arable land, trees on non-arable land, boundaries or other interstitial sites (FAO, 2013).

5.3. Global Forest Watch (GFW) / Hansen et al. (2013)

5.3.1. Overview

The Global Forest Watch (GFW) is an independent online forest monitoring platform (www.globalforestwatch.org). It was first established in 1997 by the World Resources Institute (WRI) as part of the Forest Frontiers Initiative. Initially, the GFW collected data only for the four pilot countries namely Cameroon, Canada, Gabon and Indonesia and acted as a network of NGOs. After expanding its network to other countries, undertaking projects with governments, and collecting data for nearly two decades, the WRI and a consortium of partners launched GFW 2.0 in 2014. It provides an interactive online platform with forest monitoring data for the whole world. Since then, more than 1.5 million people have visited the GFW website (GFW, 2018).

The GFW was founded as a response to a lack of information about forests. Before its establishment, the WRI saw the problem that much of the information was outdated, inaccurate, inconsistent across regions and confusing. Poor information leads to misguided forest management decisions, which affect the long-term stability of the world's forests. The WRI and GFW view forests as a vital resource that provides people with employment, food, clean water, and a carbon sink for climate stabilization (WRI, n.d.). The vision was to create a transparent, up-to-date, accurate, consistent, and free data base for monitoring forests in real time, in order to protect the world's forests from deforestation due to growing demand for food, land and timber. In order to provide data at a near real time frequency, the GFW also publishes weekly GLAD[9] (Global Land Analysis and Discovery) alerts for Indonesia and other select countries, identifying areas of near real-time tree cover loss.

GFW uses remote sensing technology to monitor worldwide tree cover loss with updates on a weekly or annual basis. It does not have one single definition for forest, but applies a variety of data sets in order to monitor different forms of tree cover including forests and tree plantations. Currently, there are five categories of data sets available: land cover, forest change, conservation, people, and climate. For the variables tree cover and tree cover loss and gain, the GFW uses the 'Hansen map' developed by Professor Hansen from the GLAD laboratory at the University of Maryland in collaboration with National Aeronautics and Space Administration (NASA), Google, and the United States Geological Survey (USGS) (Hansen, 2013; GFW, n.d.). This data set has become one

[9] The GLAD laboratory in the Geographical Sciences Department at the University of Maryland is led by Drs. Matthew Hansen and Peter Potapov. It investigates methods, causes, and impacts of global land surface change (GLAD, n.d.).

of the most used sources on forest cover and change around the world and constitutes the basis for many further studies in this field, (e.g. Margono et al., 2012; Gaveau et al., 2016).

5.3.2. Definitions

The 'Hansen map' reports 'tree cover', 'tree cover loss', and 'tree cover gain'. These terms have to be differentiated from forest cover, deforestation or reforestation, as they are solely based on tree canopy cover and not on land use. Tree cover in this sense is defined as all vegetation higher than 5 meters, hence, it can occur in the form of natural forest but also as plantations and other vegetation that meet the formal requirements. This definition has been chosen in this way because it enables the measurement with remote sensing imagery (Harris et al., 2016; Hansen et al., 2013; GFW, 2018).
Tree cover loss is defined as 'stand replacement disturbance', as a result of logging or harvesting of singular trees, or the 'complete removal of tree canopy cover at the Landsat pixel scale' (Hansen et al., 2013). Hence, tree cover loss concerns not only natural forests but all stands with canopy cover higher than 5 meters, such as palm oil or rubber plantations. Tree cover loss does not make a distinction between the long-term or short-term conversion of forest land, or whether it was a result of human or natural causes. Similarly, tree cover gain is the establishment of tree cover on land that had no tree cover before. Tree cover, loss and gain, however, cannot be accurately compared with one another, because of variations in methodology and date of content (Hansen et al., 2013). Using the interactive map of the GFW, users can filter these data according to their desired definition of forests and deforestation (e.g. baseline forest cover 2000 or 2010, or forest loss defined as canopy density of 10% up to 75% compared to baseline). With increasing technology, more detailed land uses can be viewed based on other sources (e.g. Margono et al., 2014; Gaveau et al., 2016; Potapov, 2017).

5.3.3. Methodology

The foundation of the GFW data set for tree cover and tree cover loss is built on the 'Hansen map' by Professor Hansen et al. (2013) from GLAD at the University of Maryland (Hansen et al., 2013; GFW, n.d.). It was created using Google Earth Engine, an open-access cloud platform combining remote sensing imagery and geospatial datasets with a high computing capacity to conduct planetary-scale analysis, and a nearly complete set of imagery of Landsat 4, 5, 7, and 8 satellites. Hansen et al. (2013) used cloud-free

Landsat 7 imagery from the growing season at a spatial resolution of 30x30 meters. The imagery from the growing season was used, because the data from this season are more accurate (Tucker et al., 2004). In the original study, tree loss occurred when the pixel passed under the 30% canopy cover threshold. The interactive map of the GFW, however, allows to adjust the threshold to individual purposes. The temporal resolution of the study was on an annual basis, measuring the deforestation rate for 2001 to 2012. The method used was an automated method interpreting the Landsat imagery. The numbers are automatically updated and can be viewed in near real time on the GFW, at a temporal resolution of weekly to annually.

5.3.4. Interests and purposes

The interests of the GFW and the GLAD are clearer than for other interest groups. They aim to provide coherent, transparent and up-to-date data on global forests. By providing free access to data on the state of forests which are almost real time and have a high resolution, the GFW aims to empower forest managers, law enforcement officers, and other stakeholders to better manage forests (Harris et al., 2016; GFW, 2018). As a team of scientists, Hansen et al. (2013) aimed to create a consistent, temporally and spatially explicit source of information on global-scale forest change. Before their study, such a data set did not exist, as previous efforts were based on sampled data or satellite imagery with a low spatial resolution (ibid., 2013). However, this study cannot be considered objective either, but as subjective since scientists selected the sensors, calibrated the data and chose the methods for analyzing the satellite data (United Nations Satellite Imagery and Geospatial Data Task Team, 2017).

5.3.5. Discussion

Compared to the numbers published by the MoEF and the FAO, the Hansen data set delivers the highest figures for the deforestation rate. In fact, it does not really reflect the loss of forest but of tree cover. In 2015, Hansen found a tree cover loss of 1.75 Mha for Indonesia. This is almost three times more than the deforestation rate reported by the FAO (0.68 Mha), and 460 % more than the one by the MoEF. The main reason for this lies in the definition resulting from applied methodology and interests. This has a number of advantages but also disadvantages.

The Hansen data has attracted high attention among policy-makers, scientists, and forest practitioners, because is the first global high-resolution map of global tree cover loss and gain (Bellot et al., 2017; Tropek et al., 2014). As it is based solely on remote sensing data, it is independent from traditional measurement methods, such as national reporting which can be inaccurate and inconsistent over countries (MacDicken, 2015). Therefore, the Hansen data set is consistent over different geographical and temporal scales, which makes it useful for making comparisons and a 'much needed tool for both research and conservation planning' (Tropek et al., 2014). The embedding of these data in the interactive GFW map allows for frequent and spatially precise updates.

However, there are also criticisms. Some concerns relate to the accuracy of the data set. Hansen et al. (2013) included an accuracy assessment into their study and found the overall accuracy to be over 99%. An independent assessment by Mitchard et al. (2015), however, found that the Hansen data can in some cases deliver inaccurate data, for instance when forest loss is very fragmented as in Ghana, or in cases where the automated classification method misclassified agricultural changes as forest loss. Tropek et al. (2014) estimate that forest loss in the tropics was underestimated by more than 10%. Other studies, however, found that the Hansen map is 'hugely overestimating deforestation in Indonesia' (Bellot et al., 2017; Tropek, et al., 2014). This stems from the fact that the Hansen data set does not measure actual forest cover and deforestation but tree cover and tree cover loss, which is one of the biggest criticisms. Bellot et al. (2017) compared the Hansen data with forest cover data from FORCLIME (Forests and Climate Change Programme, a bilateral program of the MoEF and the German Ministry for Economic Cooperation and Development (BMZ)) for three districts in Kalimantan. They found that the Hansen map wrongly classified smallholder agriculture, plantations, and shrub land as forest area, although they can clearly be identified in Landsat imagery as well as the FORCLIME natural forest cover map. This results in an overestimation of forest cover and deforestation alike (Bellot et al., 2017). Hence, this data set must be used with care and it has to be known that comparing this data set with those of other sources is like "comparing apples to oranges" (Hance, 2016).

Due to the limitations of the tree cover definition, later studies have tried to map the state and development of actual forest cover, building upon the Hansen map. Two studies that have done so include Margono et al. (2012) and Gaveau et al. (2016). Both studies show similar results in the numbers for annual forest in Indonesia (see Chapter 3).

5.4. Margono et al. (2014)

Belinda Margono was the former head of data-gathering of the MoF, and now works now for the University of Maryland. Together with the GLAD team, she published a landmark report stating that Indonesia's deforestation rate in 2012 was the highest in the world, even surpassing the former deforestation champion Brazil. These statistics are based on the loss of primary forest only. The study noted that the research by Hansen et al. (2013) was based on forests as defined by tree cover, which included plantations and other commercial forest dynamics in the quantification of deforestation, and therefore disaggregated forest by primary and non-primary forest cover. Primary forests for this purpose are defined as mature natural forests of at least 5 ha that retain their natural composition and structure and have not completely cleared and re-planted in recent times (Margono et al., 2014, p. 730). Primary forests include intact types, meaning without detectable sign of human alteration, and degraded types, which show signs of human disturbance, such as selective logging. Deforestation was defined as the change of primary forest to other land use. The method involved a two-step process: first, the pixels with a canopy cover of at least 30% for the reference year 2000 were filtered automatically. Second, in order to separate primary forest from other tree cover, another per-pixel-classifier was applied to retain forested areas of above 5 ha. This was followed by a manual editing process, removing older plantations and other types of tree cover in a photo-interpretative context. Primary forest was further disaggregated into intact and degraded types by using a GIS-based approach of the Intact Forest Landscape (IFL) (Margono et al., 2014). The method has been found to be very accurate and valuable in terms of forest conservation and future mapping efforts (Interview partner A, personal communication, May 10, 2018).

5.5. Gaveau et al. (2016)

A similar study based on the Hansen data set has been developed by Gaveau et al. (2016) which analyzes old-growth forests in Kalimantan and Malaysian Borneo. However, thanks to personal communication, the extended data set for the whole of Indonesia was available to the author of this report. David Gaveau is a forest and remote sensing expert, who has worked for CIFOR for many years. He and his team have developed a method based on the Hansen data set to measure tropical deforestation, which has recently been informing many institutions including Greenpeace, the WRI, and CIFOR (Interview partner A, personal communication, May 10, 2018). Old-growth forests usually include many old (>500 years) large-canopy emergent trees, and include intact and selectively-logged types. Intact old-growth forests are pristine old-growth forests, i.e. forests that have never been disturbed by humans, or for which disturbances were too localized to be detected by the satellites. Selectively-logged forests have been affected by industrial-scale mechanized selective logging at some point since logging activities began in the 1970s (ibid., May 10, 2018). Selectively-logged forests have lost their original structure but have remained in good condition and regenerate quickly (ibid., 2018). This definition of forest excludes young forest regrowth, scrublands, tree plantations, agricultural land, and non-vegetated areas. The latter are considered non-forest areas. In this sense, forests are closed-canopy (>90% cover) and high carbon stock (Above Ground carbon: 150 - 310 Mg C/Ha) evergreen dipterocarps growing on either mineral or peat soils. On peat domes, forests include low carbon stock pole forests. In highland regions, forests include 'cloud forests' (*'kerangas'*), which are naturally shorter and have less canopy cover (Butler, 2012). In coastal areas, it includes mangroves. Annual forest loss represents the area of intact and selectively-logged forest that has been cleared every year since 2001 until 2017 because of conversion to industrial and smallholder plantations, forest fires, infrastructure developments, open-pit mining and reservoirs for hydropower dams. Annual forest loss was extracted from the most recent annual tree loss map created by (Hansen et al. 2013), revealing areas of tree cover (>30%; tree height >5m) cleared every year from 2001 to 2016. In order to filter only natural forests, an evergreen rainforest area mask was applied for the year 2000, the baseline for measuring forest loss. The results from this study are similar to the figures found by Margono, which might suggest that both sources provide reliable figures for the annual deforestation in natural forests.

6. Results & Discussion

The aim of this thesis was to analyze the main sources for the deforestation rate in Indonesia and to understand why their numbers differ from each other. The thesis analyzed the rates of forest loss reported by the MoEF, the FAO and Hansen et al. (2013), as well as by Margono et al. (2014) and Gaveau et al. (2016). The majority of deforestation rates have varied across different sources in the last decade (see Section 2). Only the data sets from Margono et al. (2014) and Gaveau et al. (2016) showed similar results. The findings of this thesis suggest four factors causing these variations: Interests and purpose of existence of the respective institutions, definitions of forests and deforestation, methodology and technology of measurement of forest cover and changes, and other factors relating to governance issues in the context of the Indonesian MoEF. Figure 6.1 shows an overview of the factors which were found to cause the variations in the deforestation rate by the different sources. The following section summarizes and discusses these factors in more detail.

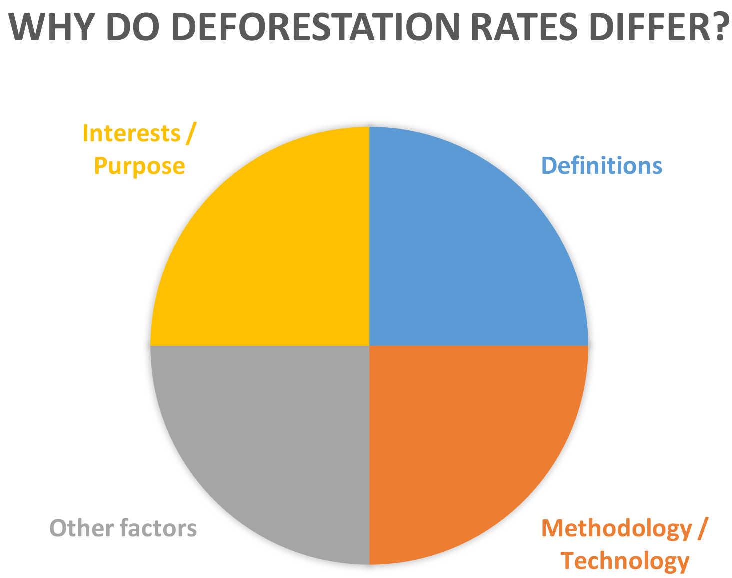


Figure 6.1. Factors causing variations in the deforestation rates measured by different sources

Interests / Purpose

This study observed a strong influence of the interests and the purpose of existence on the formulation of forest definitions applied by the different actors. Table 6.1 provides an overview of the respective interests of institutions and their perspectives on forests, as well as their definitions of forests and forest loss, and forest classifications. For instance, one of the FAO's aims is to secure timber supply, which is reflected in its definition of forest as a resource for timber (Chazdon et al., 2016; FAO, 2015). The MoEF sees forests as a national dominion which is reflected its definition of forests being an officially designated area (MoEF, 2016; Chazdon et al., 2016; Indrarto et al., 2012). Hansen et al.'s (2013) vision was to create a global tree cover map, which was enabled through the use of satellite data and a method that automatically measured tree canopy cover. Building upon this study, Margono et al. (2014) and Gaveau et al. (2016) extended the satellite-based research for primary forests and old-growth forests respectively, and aimed to capture the changes of primary and old-growth natural forests only. Hence, actors are governed by their interests and purposes of existence in the formulation of definitions and selection of methodologies. How forests are defined and measured, therefore, is a reflection of the measuring institutions' interests and purpose of existence. These findings are in line with Purnomo et al. (2012), who found that in the Indonesian region Jambi, REDD+ actors were governed by their interests. It also reinforces Chazdon et al.'s (2016) hypothesis that the definitions of forests are determined by the lenses through which forests are and want to be seen by different institutions.

The pursued interests can stem from an institution's purpose of existence, such as maintaining the control over national dominion in the case of the MoEF, or guaranteeing the supply of food and timber in the case of the FAO. However, this thesis also found that institutions cannot be regarded as homogenous constructs that always act according to one stated goal. In fact, interests within institutions can stand in conflict to each other. For instance, the MoEF's mission is to protect forests and the environment, while at the same time issuing logging concessions for plantations and agricultural purposes (Indrarto et al., 2012; Jakarta Globe, 2014). Moreover, the interests in the MoEF can vary on different levels of government, resulting in a complex set of different interests from the local to the national level (Burgess et al., 2012; Indrarto et al., 2012; Enrici and Hubacek, 2016). As decentralization has resulted in overlapping and a relatively equal legal authority of the national and local governments over land-use and allocation, local governments' interests are an integral part of actual forest governance and its implementation (Indrarto et al., 2012; Enrici and Hubacek, 2016). In the competition for budget, political authority and legal mandates, local governments take advantage of decentralization policies and use them to their own advantage according to their personal interests (ibid., 2012, 2016; Burgess et al., 2012). Not only the MoEF, however, was found to have conflicting interests; additionally, the FAO's interests are inherently dispersed. The goals of the FAO include the eradication of hunger and the secure supply of food, while at the same time it aims to guarantee the supply of timber products and sustainable forest management (FAO, 2015). Hence, the conflicting interests can lead to trade-offs between the provision of land for agriculture and forestry and the conservation of forests and the extraction of non-timber forest products (Illukpitya and Yanagida, 2010; Pattanayak and Sills, 2001).

Conflicting interests regarding forests might lie in the fact that land is a scarce resource, which is needed for the supply of a variety of products, services and economic income. The allocation of land is governed by the interest to maximize benefits (Pattanayak and Sills, 2004).

The interests of actors are often seen as coherent and unified, which are equally pursued by one institution (Chazdon et al., 2016; Purnomo et al., 2012). While this study recognized that institutions are governed by their interests and define and monitor forests and forest loss according to the stated goals, it also points out that interests of institutions have to be regarded with care and the awareness that institutions can also act contrary to their stated interests. Commons (1931) equally found that institutions are marked by various aspects and interests, ranging from a common interest to individual behavior of the 'inmates' themselves.

A determining factor in the pursuit of interests is the availability of financial funds. Institutional capacity is framed within the financial possibilities of capital sponsoring sections (Hall, 1979, read in Maxton-Lee, 2017), hence donors determine whether an interest can be pursued or not. The FAO, for instance, is sponsored at more than 60% by voluntary donors (FAO, 2013), who provide funds in order to gain some marginal benefit in return (Harvey and Wood, 1996). Possible fields of interest to donors could include for instance the choice of tree species, intercropping on arable land, trees on non-arable land, boundaries or other interstitial sites (FAO, 2013). Maxton-Lee (2017) argues that leaders act to stay in power and have to represent national interests as well as the interests of providers of capital. Considering that national and international interests build on a common sense for development and economic growth (Maxton-Lee, 2018), it becomes clear that the allocation of financial resources determines the interests pursued by institutions and hence defines the fate of forests.

Table 6.1. Purpose, interests, perspective on forests, and definitions

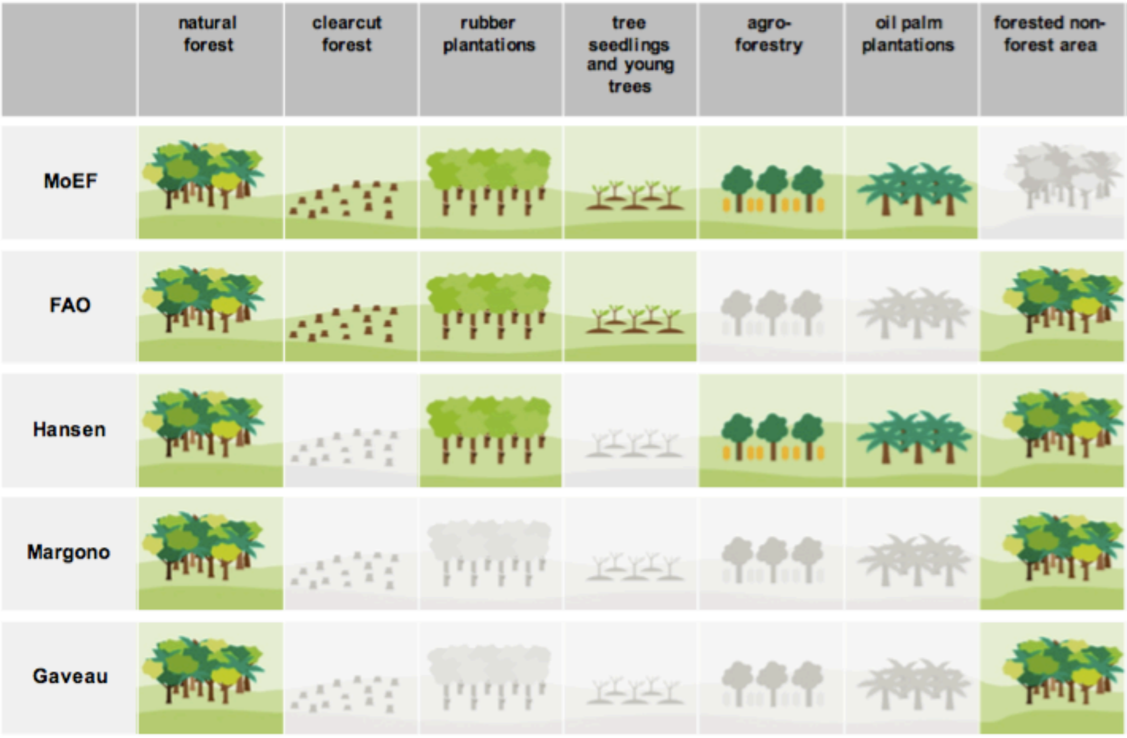
	MoEF	FAO	Hansen / GFW	Margono	Gaveau
Purpose of existence	Manage official forest land	Secure food and timber supply	Publish scientific reports	Publish scientific reports	Publish scientific reports
Interests	Protect environment, preserve forests, issue concessions for logging and plantations, economic growth, personal interests, etc.	Sustainable agriculture and forestry	Provide accurate and timely information about global tree cover and changes	Map primary forests and their changes	Map old-growth forests and their changes
Perspective on forests	State domain	Resource for timber	Tree cover	Ecosystem	Ecosystem
Forest definition	Territory designated by the government ('kawasan hutan')	Land of at least 0.5 ha with trees (potentially) higher than 5m, a canopy cover of (potentially) 10%.	Tree cover, defined as all vegetation taller than 5 meters in height.	Primary forest cover - mature natural forests of 5 ha or more that retain their natural composition and structure.	Old-growth forests - many old (>500 years) large-canopy emergent trees.
Deforestation	Change from official forest land to non-forests	Change from forest to other land use, or the permanent reduction of canopy cover below 10%.	Tree cover loss, defined as stand level replacement of vegetation greater than 5 m.	Primary forest cover loss	Tree cover loss, as defined by Hansen, excluding non-forest area.
Forest Types	Primary | Secondary | Plantations // Conservation | Protected | Production forests | KSA | KPA	Primary | Other Naturally Regenerated | Planted | Mangroves | Production | Multiple Use Forest	N/A	Primary intact | Primary degraded forest	Intact | Selectively-logged old-growth forests

Table compiled by the author, using information from MoEF (2016), FAO (2015), Hansen et al. (2013), GFW (2018), Margono et al. (2012), Margono et al. (2014), Gaveau et al. (2016).

Definitions of forests

All the examined sources for the deforestation rate showed different definitions of what constitutes a forest from their point of view. Table 6.2 gives a simplified overview of examples that are considered as forest land according to the different definitions. The MoEF definition of forest is an area officially designated as forest land, consisting of conservation, protection and production forests, but it does not include land that is not officially designated as forest land even if it is covered by forest. At the same time, provided it is legally designated, official forest area can in principle encompass all forms of land cover, even plantations and grass land (Indrarto et al., 2012; Enrici and Hubacek, 2016; MoEF, 2016). Compared to other sources, the MoEF reported the largest forest area for Indonesia in 2010, which might be explained by considering the fact that 'production forests' such as plantations and agro-forestry are regarded as forests. On the other hand, the FAO defines forests as a resource for timber, regardless of whether they are mature or clear-cut. By its definition, the FAO includes all forested areas of at least 0.5 ha with trees (potentially) higher than 5 meters and a canopy cover of (potentially) 10%. These thresholds define forest regardless of whether the land area is officially recognized by the MoEF, however, in how far the reporting of the NCs reflect the existence of officially and non-officially recognized forest area as reported by the MoEF, could not be determined in the course of this thesis. Hansen et al.'s (2013) definition of forest is determined by tree cover and includes all vegetation higher than 5 meters. Margono et al. (2014) and Gaveau et al. (2016) used the Hansen data set to measure primary forest cover of at least 5 ha and old-growth forests older than 500 years respectively.

Table 6.2. What is considered as forest?



Graphic compiled by the author, using data from Harris et al. (2016), MoEF (2016), FAO (2015), Hansen et al. (2013), GFW (2018), Margono et al. (2012), Margono et al. (2014), Gaveau et al. (2016).

Deforestation / Tree cover loss

The definition of forest area determines what is measured as deforestation or tree cover loss. The basic definition for deforestation, which is valid for all sources, is defined as the conversion from forest to non-forest land (Lund, 2018). In light of this definition, it becomes clear that forest loss is measured on the basis of forest area. The variations in forest definitions therefore lead to different understandings of deforestation. For instance, the replacement of natural forest by tree plantations is reported as tree cover loss only by Hansen et al. (2013), Margono et al. (2014) and Gaveau et al. (2016), if the type of natural forest corresponds to their respective forest definitions.

The definition of deforestation, however, is interpreted with different principles of forest change, which are based on land use or land cover change. The MoEF (2016) and the FAO (2015) define deforestation as the change from forest land to another land use. Hence, those sources report a land use change, where it is relevant what kind of land use follows the clearing of forest land. If the subsequent land use is considered to fall under the definition for forests, then no change is reported. For instance, as both the MoEF and the FAO consider tree plantations as forests, no deforestation is reported if natural forest is cleared and subsequently replaced with timber plantations. In contrast, Hansen et al. (2013), Margono et al. (2014) and Gaveau et al. (2016) define tree cover loss or forest cover loss as the stand level replacement or loss of the defined forest areas. Hence, they report a land cover change, which is based on actual tree cover and its changes. For the latter three studies, it is therefore irrelevant which land use follows after clearing. Table 6.3 shows some examples of what is reported as forest change by the different sources.

Table 6.3. What is reported as forest change?

Before	Change	After	MoEF	FAO	Hansen	Margono	Gaveau
Natural forest	Clear-cut	Farmland, housing, other land use	deforestation (if official forest)	deforestation	Tree cover loss	deforestation	deforestation
Natural forest	Clear-cut	Tree plantation	NO CHANGE	NO CHANGE	Tree cover loss	deforestation	deforestation
Natural forest	Fire	Natural regrowth	NO CHANGE	NO CHANGE	Tree cover loss	deforestation	deforestation
Natural forest	Clear-cut	Palm oil plantation	NO CHANGE	deforestation	Tree cover loss	deforestation	deforestation
Natural forest	Clear-cut	Rubber/cork plantation	NO CHANGE	NO CHANGE	Tree cover loss	deforestation	deforestation
Tree plantation	Clear-cut and replant	Tree plantation	NO CHANGE	NO CHANGE	Tree cover loss	NO CHANGE	NO CHANGE

Graphic compiled by the author, using data from Harris et al. (2016), MoEF (2016), FAO (2015), Hansen et al. (2013), GFW (2018), Margono et al. (2012), Margono et al. (2014), Gaveau et al. (2016).

Forest classification

Some scholars noted that different classification schemes for forests can provide a source for discrepancies in deforestation rates from different sources as well (Indrarto et al., 2012; Enrici and Hubacek, 2016). In the case of the MoEF, it was reported that the complex forest classification scheme allowed for increased opportunities for corruption and led to the mismanagement of resources (ibid., 2012, 2016). Hence, it is possible that different forest classification schemes contributed to different numbers for the official deforestation rate, however, their actual effects on the distortion of deforestation rates still require examination in further studies.

While complexity of forest classification systems reduces the ability to implement policies (Purnomo et al., 2012), forests on the other hand are inherently diverse and need to be classified into detailed categories (Cerutti and Nasi, 2014). This suggests that a balance between complexity and simplicity of classification schemes must be found and trade-offs are inevitable.

Methodology

Accounting method - 'Net' versus 'gross' deforestation

Another factor for why deforestation rates differed across different sources was how forest gain and afforestation were accounted for. Hansen et al. (2013), Margono et al. (2014) and Gaveau et al. (2016) reported 'gross' deforestation, which did not consider forest gain or afforestation in their numbers. On the other hand, the MoEF (2016) and the FAO (2015) reported 'net' deforestation, which deducted the establishment of forest on previous non-forested area (afforestation) from gross deforestation. However, it is argued that afforestation could not be seen as the opposite of deforestation because it is usually more fragmented and takes at least the same time of the previous forest's age to reproduce a forest of the same structure and ecological value (Brown and Zarin, 2013; Chazdon et al., 2016; Tropek et al., 2014). Moreover, forest definitions that are widely used for the assessment of forest loss are not suitable for the assessment of forest gain and afforestation (Chazdon et al., 2016). There is further criticism on the 'net' deforestation approach for equating the value of native forests with newly planted ones and for confusing and misleading 'zero deforestation efforts' by governments, corporations, and civil society organizations (Brown and Zarin, 2013).

Measurement technology

The technology and method of measurement of forest cover and its changes constitute another source of discrepancies in deforestation rates from different sources (Interview partner A, personal communication, May 10, 2018). The applied technologies include traditional methods such as national accounts and academic studies, and satellite-based technologies. For instance, the MoEF (2016) uses Landsat imagery for assessing forest area and changes, but it also requires traditional sources for the determination of officially-recognized forest area. The FAO (2015) relies on the data reported by various nations, hence, it incorporates data measured by traditional and satellite-based technologies. Hansen et al. (2013), Margono et al. (2014) and Gaveau et al. (2015) completely rely on satellite imagery. However, there are different methods for the interpretation of such images, which can produce different results as well. While the MoEF, for instance, applied visual (manual) interpretations of satellite imagery (ibid, May 10, 2018), Hansen et al. (2013) and Gaveau et al. (2016) used an automated approach. Margono et al. (2014) chose a semi-automated interpretation method. While an automated approach allows for a coherent, large-scale and low-cost interpretation of satellite imagery, it can also show mistakes in interpretations (ibid., May 10, 2018). On the other hand, visual interpretations are conducted by humans, and therefore can be more accurate, but are more expensive and difficult to validate (ibid., May 10, 2018). Hence, the differences in interpretation methods can also influence differences in measured deforestation rates. Table 6.4 gives an overview of the methods applied by the reviewed sources.

Table 6.4. Methodology

	MoEF	***FAO***	***Hansen***	***Margono***	***Gaveau***
Net / Gross deforestation	*net*	*net*	*gross*	*gross*	*gross*
Measurement	*LANDSAT / visual interpretation*	*Various sources / based on MoEF*	*LANDSAT / automated interpretation*	*LANDSAT / semi-automated interpretation*	*LANDSAT / automated interpretation*

Sources: MoEF (2016), FAO (2015), Hansen et al. (2013), GFW (2018), Margono et al. (2014), Gaveau et al. (2016), Interview partner A, personal communication (May 10, 2018).

Other factors

Decentralization

Several governance issues were found to have an influence on the MoEF's reporting of deforestation. Decentralization, for instance, has led to overlapping and relatively equal legal authorities over land-use and allocation, which allowed for wide-spread corruption on the local government level and the pursuit of local leaders' personal interests (Indrarto et al., 2012; Setiawan et al., 2016; Saputra, 2018). Decentralization was found to be connected and the conversion from official forest land to non-officially recognized forest land and their subsequent conversion (ibid., 2012; Setiawan et al., 2016; Burgess et al., 2012). Decentralization gave rise to a clash of interests on different governmental levels, which has further been complicated by the merger of the MoF and the MoE in 2014. The conflicting interests have led to conflicting data alike and subsequently to the potential distortion of the reported forest loss. The fact that deforestation of non-officially recognized forest land is not included in the official deforestation rate reported by the MoEF (MoEF, 2016) leads to further distortions of the reported numbers.

Conflicting data within MoEF

Decentralization empowered local leaders to issue logging concessions on their own (Setiawan et al., 2016; Saputra, 2018), which contributed to differences in the forest cover maps and data on different government levels. Conflicting numbers within the MoEF raise the question how they are handled by the MoEF. The extent to which conflicting land cover maps from local levels are considered in the official numbers by the MoEF instead of the numbers recorded on the national level could not be answered within the scope of this study. However, interview partner A (personal communication, May 10, 2018) noted land use changes were not always reported by the MoEF as they could actually be identified on satellite imagery (ibid., May 10, 2018). This might suggest a possible answer to that research gap, given that the MoEF could in some cases refer to the land use and change maps from local governments instead of the images taken by satellites. However, these findings require validation in further research.

Culture of secrecy

There is a myriad of governance issues that influence the deforestation rates reported by the MoEF. However, many of them cannot be fully understood due to a culture of secrecy. The MoEF has not been responsive in providing information for this thesis either, which has left several data and information gaps open and unexplained. Information gaps include whether and how illegal land use changes are considered in the measurements of the deforestation rate, and why some changes identified by other studies using satellite imagery are not reported by the MoEF, although they use satellite imagery as well.

Implications

Actors are governed by deep-rooted interests that often have their origins in their purpose of existence. Those interests determine how forests are defined and measured. Although experts argue that it is necessary to find a common understanding of forests and forest loss in order to protect them (Cerutti and Nasi, 2014), this thesis finds it unlikely to happen in the near future. Considering the existence of a myriad of different interests in forests by different stakeholders, it is improbable that one common definition will be found in the future. Therefore, this thesis suggests the acceptance of discrepancies in data from different sources. However, it is vital to apply the data wisely and in correspondence to stated goals and interests. A suggestion of which data sources to apply for which purposes can be found in Table 6.5.

This thesis suggests that not all data would equally inform policy decisions, but they are suitable for different purposes. For instance, the MoEF's numbers for deforestation are based on legal designations and do not only represent actual forest cover. Hence, the MoEF's data would be applicable to certain purposes, which require information about legal, official land use designations by the government. On the other hand, the FAO defines forests as a resource for timber supply, hence, their numbers could be used as a source of information for studies on timber potential and plantation management. Tree cover as measured by Hansen et al. (2013) measures all actual tree cover and could therefore with caution be used for carbon emissions monitoring from land use changes (Harris et al., 2012). On the other hand, efforts that have mapped natural forests with original structure and composition (Margono et al., 2014; Gaveau et al., 2016) could be used for making decisions and policies on conservation, biodiversity and ecosystem functions.

Table 6.5. Suggestions for application of data in different fields

	Fields of application of deforestation rates
MoEF	Official government data / detailed land use designations / legal designations
FAO (2015)	Forest and plantation management / timber supply
Hansen et al. (2013)	Climate change / carbon storage / timber supply
Margono et al. (2014)	Conservation / biodiversity / ecosystem services
Gaveau et al. (2016)	Conservation / biodiversity / ecosystem services

Examples of application of inappropriate data

Considering the suggestions from above, there are several examples from practice which apply inappropriate data as indicators. For instance, SDG 15 (Life on Land) aims to conserve ecosystems, preserve forests and biodiversity (UNSTATS, 2015). However, the indicator used to implement this goal is forest area and forest changes as reported by the FAO (ibid., 2015). However, as discussed in this thesis, the FAO definition includes tree plantations and even clear-cut land in its definition of forests and does for instance not report deforestation when a natural forest is replaced by tree plantations. Hence, the defined indicator here does not correspond to the stated target. Monitoring forest and biodiversity conservation does not make sense using FAO data. Another example which uses inappropriate data is the Convention on Biological Diversity (CBD). The CBD aims to conserve forests biodiversity but uses FAO data for forest area and changes (United Nations, 1995; Grainger, 2008; Convention on Biological Diversity, n.d.). In order to monitor conservation efforts and to achieve the stated goals, the data from the FAO are not appropriate, but should be replaced with data from sources measuring natural forests, such as Margono et al. (2014) and Gaveau et al. (2016).

'Zero deforestation' commitments

Governments and companies are often pledging for 'zero deforestation' commitments, however, considering the points discussed in this thesis, these efforts are flawed. There is no general definition of 'zero deforestation' (Brown and Zarin, 2013), which means that both 'net' and 'gross' deforestation approaches can be used for the assessment of deforestation in this regard (ibid., 2013). Still, the existence of 'net' and 'gross' deforestation is often not yet known to data users, or at least is not well understood (ibid., 2013). However, 'net' deforestation erroneously equates the value of newly planted forests with native natural forests (ibid., 2013). This has led for instance to mistakenly reported success stories of 'zero deforestation' commitments and the mistaken belief that forest conservation goals have been achieved (ibid., 2013). Hence, FAO data on net deforestation are not appropriate for conservation purposes or 'zero deforestation' commitments. This is alarming, as the FAO data and definitions are the most widely used and constitute the basis for a number of forest conservation efforts as well (Grainger, 2008). This thesis suggests that 'zero deforestation' commitments should not be based on 'net' values, but on 'gross deforestation' in order to capture an appropriate and realistic image of forest loss.

6.1. Limitations

The research in this thesis faces several information and data gaps. First, the data for deforestation rates and forest area from different sources indicates several data gaps. The reason for this have been fragmented and often opaque data sets, especially from the MoEF, which was not willing to fill any gaps or provide materials on how the deforestation rate is derived in detail. Hence, this thesis relied on secondary literature to fill some of the gaps (e.g. Indrarto et al., 2012; Margono et al., 2012) and collect information on possible impacts that cause the discrepancies in deforestation rates compared to other sources.

The unwillingness to share data and a 'culture of secrecy' of the MoEF left some questions open, which could not be answered by the available sources. Information gaps which remain unfilled include the actual influence of forest classification schemes on reported deforestation rates. Furthermore, an open question is how the conflicting data on different government levels is handled by the MoEF.

As the drafting period of this thesis was limited in time and research materials, the factors that were found to influence the discrepancies in data are not exclusive or comprehensive. There probably are other factors which cause the deforestation rates to differ, however, this study was limited to findings which could be drawn from available literature and studies. Hence, in order to reveal possible other factors that cause deforestation rates to differ, further research is required. While forest classification schemes were suggested to cause discrepancies (Indrarto et al., 2012), their actual impact is still subject to further evaluation.

7. Conclusion

The purpose of this thesis was to analyze the main sources for the deforestation rate in Indonesia and to understand why their numbers differ from each other. This study showed that most of the numbers for the deforestation rate differ heavily for Indonesia in the last decade and that there is a lack of a general consensus of the actual extent or the trend of deforestation in Indonesia. Most importantly, the thesis identified four major factors which caused the discrepancies between the data on forest loss from different sources. These factors include interests and purpose of the respective institutions, definitions for forest and forest loss, methodologies of measurement, and other issues in the context of Indonesia.

This study identified a strong influence of the institutions' interests and their purposes of existence on the formulation of definitions of forests and forest loss. Forests therefore are defined from different vantage points, which is reflected in the fact that all the reviewed sources had different definitions of forests and forest loss. For instance, while the MoEF defines deforestation as a loss of officially designated forest area, the FAO views deforestation as the loss of land for potential timber products. While Hansen et al. (2013) measure total tree cover loss on a global scale, Margono et al. (2014) and Gaveau et al. (2016) consider primary and old-growth forests only. These definitions correspond to the actors' interests and purposes of existence. Hence, the varying interests are a major cause of the discrepancies in deforestation rates.

However, the study also showed that actors cannot always be seen as one homogenous entity. The MoEF is not a coherent construct pursuing one single set of interests. Decentralization and the merger of the former MoF and the MoE have resulted in a clash of pursued interests within the ministry. What is more, the authorities governing land-use and allocation across different levels of government are overlapping and legally relatively equal. Therefore, also local government's interests are equally vital in forest governance. In the competition for budget, political authority and legal mandates, local leaders often take advantage of decentralization policies to pursue their personal interests. Hence, the interests of the MoEF cannot be seen only from a top-down approach, but are the product of many individuals in a decentralized system following different objectives.

One of the most important findings in this thesis was that a distinction has to be made between net and gross approaches of measuring deforestation. While the MoEF (2016) and the FAO (2015) reported net deforestation, Hansen et al. (2013), Margono et al. (2014) and Gaveau et al. (2016) measured gross deforestation. An issue concerning net deforestation is that regrowth of new forest on deforested land cannot be equated to native natural forests. Particularly when 'zero deforestation' policies are decided, it is vital to understand and clarify the difference between both approaches and choose one of them. However, it is strongly recommended to use the gross deforestation approach in this context, as it actually represents what the term promises: zero deforestation.

Discrepancies in deforestation rates have existed throughout history (Sunderlin and Resosudarmo, 1996) and will continue to persist in the future. Hence, this thesis suggests accepting these differences but choosing the data wisely. The interests of actors that measure deforestation should ideally correspond to the interests of application. Policies and decisions need to be informed by appropriate data. However, conservation efforts often use data that was collected for other purposes and fail to depict the information required to implement and monitor stated conservation goals.

This study contributes to the understanding of discrepancies in deforestation rates from different sources. Moreover, it will be of interest for future research in that it raises awareness of the possible application fields of the data on forest cover and changes from different sources. The study should inform decision makers that data on forest cover and forest loss has to be used with caution. It further contributes to the understanding of the different interests, definitions, methods and governance issues by various sources for the deforestation rate in Indonesia. Moreover, the reasons for the discrepancies in deforestation rates are applicable to other countries and other institutions as well, which provide guidance for the analysis of those discrepancies. It has to be noted, however, that this is not an exhaustive list of factors that can cause differences in data.

Several questions still remain to be answered. As this thesis was limited to available literature and expert interviews, it is neither comprehensive nor exhaustive. There is the possibility of other factors causing the discrepancies in data on forest cover and their changes, which have not been analyzed in the course of this thesis. Moreover, the influence of forest classification schemes and conflicting data within the MoEF requires further evaluation in future studies. An interesting question for future research would be to what extent the discrepancies in data on deforestation affect global conservation efforts and whether the goals of policy makers and conservation efforts are actually undermined by the hidden interests behind the data they apply.

Differences in the deforestation rates from different sources will not be resolved in the near future. Therefore, it is vital for future decisions and research to understand the underlying factors that cause those discrepancies. It needs to be acknowledged that the data on deforestation is subjective and is shaped by the interests of actors. In order to make appropriate policies and decisions, it is necessary to cooperate with the interests of the institutions who provide the data on forests, in order to meet stated goals. In the future, improved and new remote sensing technologies might contribute to the increased objectivity of data (Jones, 2017). However, as data is produced and used by humans, it will never be purely objective.

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Interview partner A, Specialist in GIS and remote sensing forest cover and their changes, associate of CIFOR and consultant for other international institutions such as Greenpeace and WRI. *Skype interview*, May 10, 2018.

Interview partner B, Program manager at CIFOR providing general expertise on interests of different actors. E-Mail correspondence, May, 2018.

Interview partner C, Team leader at Greenpeace International, currently working on a comparative study on the data on deforestation rates from the MoEF and other sources. E-Mail correspondence, May, 2018.