Beyond the myths about Indonesia’s deforestation: linking oil palm cultivation to forest degradation and sustainable development goals

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Abstract. Oil palm cultivation is under scrutiny by various stakeholders, arguing that it is the main cause for Indonesia’s deforestation. This paper highlights the decades of forest degradation before the first land clearing for oil palm within the context of Indonesia’s development policies. Using ‘direct photointerpretation’ of ‘Historical Imagery’, it assesses the forest degradation and deforestation caused by oil palm cultivation in Indonesia, particularly in light of the UN Sustainable Development Goals (SDGs). Forest degradation has direct trade-offs with most of the SDGs, with the most affected SDGs being Responsible Consumption and Production (SDG12) and Life on Land (SDG15). Historical satellite imagery indicates that the first land clearing for the 176 Kha of oil palm estates sampled palm occurred around 1994. In contrast, only half of this area contained (natural) forests in 1984— a decade before the first land clearing. None of the remaining forests were (near) intact natural forests; all were (heavily) degraded and their biodiversity was strongly compromised. This indicates that oil palm cultivation is not linked to the degradation of Indonesia’s natural forests. Regarding SDG12, we found significant positive impacts from both the direct and indirect land-use changes by oil palm. For SDG15, we observed major positive impacts from the direct land-use changes and minor positive impacts from the indirect land-use changes. Hence, we conclude that oil palm cultivation in the sampled estates has positive impacts on Indonesia’s SDGs and Indonesia’s development policies align with its SDGs.

1. Introduction

Oil palm cultivation is under severe international condemnation. Activists, alarmists and influencers alike argue that its cultivation is the key driver for deforestation worldwide, particularly in Indonesia and Malaysia [1,2,3]. One journal’s short communication even argues that “almost intact tropical forests were depleted in very recent times (<30 years) to leave space for oil palm plantations” [4]. Based on comparable arguments, in 2019 the European Union banned the use of palm oil in biofuel under its Renewable Energy Directive [5,6].

However, science sketches a more complex relationship between forest degradation, deforestation and oil palm cultivation. The large majority of Indonesia’s natural forest loss was degraded forest prior to conversion and its forest stock decreased mainly due to forest degradation, while only ¼ decreased
due to deforestation [6–8]. For example, of the natural forest lost on Sumatra Island only 3% (¼ Mha during 1990-2010) was intact forest [9]. Oil palm cultivation is linked directly and indirectly to half of Indonesia’s deforestation during 2010-2015 and less than a fifth throughout 2010-2015 [7,10,11]. For instance, Sumatran plantations have increasingly expanded onto non-forest land [10].

Indeed, the decades of forest degradation linked to various commodities—like banana, cocoa, coconut, coffee, paper & pulp, pineapple, rice, rubber, tea, vanilla, vegetables; as well as the timber, transmigration, and wildfire booms [7,12,13] – all are conveniently being “forgotten” [12]. Similarly, the deforestation–up to 700% that of palm oil [13] – associated with these commodities is likewise being “forgotten”.

With over 50 definitions of ‘forest degradation’, there is serious ambiguity over defining it but forest degradation concerns the gradual decline in structure, composition and functions upon which the vigour and resilience of a forest are based [14,15]. Forest degradation results in significant changes in species composition, both in flora and fauna, as well as changes in forest structure [8,12,14,15]. For biodiversity conservation, Indonesia’s intact (rain)forests are the most important for a significant proportion of rare, threatened and/or endangered species that are less tolerant to disturbances [16]. The role of degraded forest land in biodiversity conservation depends on the degree of degradation, connectivity to native forests and the intensity of management [12].

Hence, where forest degradation ends and deforestation begins, as well as the role of oil palm cultivation in both, remain emotive debates that span multiple decades (see Figure 1 [17]). Common causes for forest degradation in the tropics include selective logging, large-scale and open forest fires; the collecting of non-timber forest products and wood for fuel; the producing charcoal, grazing, sub-canopy fires and shifting cultivation, while estate crops like oil palm, pulp & paper and rubber are linked to deforestation [12,18,19]. Numerous attempts have been made to assess forest degradation and deforestation through remote sensing, with limited uptake [20]. However, two recent studies indicate that Google Earth’s Historical Imagery may allow for a visual appraisal of forest degradation and oil palm expansion over time [4,21].

In 2015, Indonesia adopted the 17 Sustainable Development Goals (SDGs), covering the three pillars (prosperity, people and planet) of sustainable development. The SDGs provide a global platform to map the progress towards sustainable development [22]. Forest degradation and conservation are regularly linked to the SDGs [23,24], often through their environmental services and/or ecosystem services. However, the available literature suggests that the impacts of forest degradation and conservation on various SDGs are not fully recognised [24]. Thus, it is important for all stakeholders to further explore the impacts of their actions on the SDGs using scientific approaches.

In this paper, we explore the role of oil palm cultivation in forest degradation and deforestation and their impacts on SDG12 (Responsible Consumption and Production) and SDG 15 (Life on Land). These SDGs were selected based on their key roles in the management of forests and estate crops [25,26]. Formed on visual assessments of land use change, we modelled the impacts on selected SDGs to determine changes over time.

2. Materials and methods

Using an online dataset of 77 Indonesian oil palm estates [27], we randomly selected 16 samples (see supplement, Part A). We produced high-definition Historical Imagery for each sample using Google Earth Pro to identify the main trends in forest degradation and deforestation, set at 8-year intervals (1984, 1992, 2000, 2008 and 2016) and set at a range of 35,000-40,000 meters to provide the context of
the wider landscape (see supplement, Part B). Following the visual damages of forest degradation [21], we applied “direct photointerpretation” [4] to determine the extent of each level of forest degradation (F1-F5) as well as the extent of oil palm and other non-forest cover our Historical Imagery (see supplement, Part C). We verified our interpretation against independent sources detailing forest degradation, deforestation and/or oil palm cultivation (see supplement, Part D).

To determine the impacts of oil palm cultivation on forest degradation, deforestation and SDGs 12 and 15 we used the following methods:

a. For SDG12 (responsible consumption and production) we used the trends in certification of sustainable palm oil as proxies [28,29]. As oil palm cultivation results in both negative and positive environmental/social impacts [30,31], the need for deforestation-free cultivation and management of it is crucial. With mandatory and mandatory certification initiatives raising both the floor and ceiling respectively for deforestation-free and responsible management, the production of palm oil certified by mandatory Indonesian Sustainable Palm Oil (ISPO) and the voluntary Roundtable on Sustainable Palm Oil (RSPO) initiatives impact SDG12 [32] provide tentative trends on SDG12. (Other voluntary standards, like the International Sustainability and Carbon Certification and Sustainable Biomass Programme, are also relevant to palm oil production but set requirements similar to those by the ISPO and RSPO [33,34]). We assumed a worst-case scenario for oil palm cultivation (no sustainable practices until certification) and better-case scenarios for the management of agricultural lands and forests (improving sustainable practices since 1984).

b. For SDG15 (Life on Land) we used the Forest Equivalence [7] for each land use as proxies for the impacts of oil palm cultivation. Changes in tree age structure, canopy, undergrowth, and differences in microclimate and human disturbances during forest degradation are well researched [7,35,36]. Less information is available on the Forest Equivalence of oil palm plantations and they are structurally less complex than natural forests [7]. Yet, responsibly managed oil cultivation does maintain substantial biodiversity [7,37,38]. Hence, we set the Forest Equivalence for F1-F5 forests at 100%, 95%, 75%, 50% and 15% respectively, and for oil palm and agricultural mosaics at 25% and 10%.

3. Results and discussion

Google Earth’s Historical Imagery resulted in an inconsistent quality of image quality throughout the years, shown in Figure 1. In older imagery, multiple layers of erased clouds can be observed – especially in the 1984, 1992 and 2008 Historical Imagery- while their shadows remain and can appear as intact rainforest to the untrained eye (see Figure 2). Furthermore, earlier satellites provided imagery with resolutions of 15-60 meters, whereas more recent imagery (after circa 2000) has resolutions down to 1½-2½ meters [39,40]. The improved resolution also improves the visual assessment of Historical Imagery since 2000.

The Historical Imagery indicates that a decade prior to the first land clearing for oil palm estates (1984), almost ½ of the area in our samples was already deforested (samples no 1,5,9,11,14) while sources record deforestation prior to 1973 for some samples (e.g. Zuckerman [3], Hinkes [7], and Gibson et al. [16]). Around the time of the first land clearing for oil palm cultivation (1992), less than half of the area contained forests. Forest degradation and deforestation doubled throughout 1992-2000 and levelled off during 2000-2016. None of the remaining forests were (near) intact (F1-F2) forests between 1984-2016. Only 4 of the 16 samples (samples 6, 10, 13, and 15) contained large areas of lightly degraded or degraded (F3-F4) forests prior to 2000.

![Figure 2](image-url)
Our findings furthermore indicate that a simple rule-of-thumb can be defined regarding Indonesia’s deforestation: it is in roughly equal parts (50% each) due to forestry and non-forestry activities, while the latter can be broken down into roughly equal parts (25% each) due to oil palm and other crops.

Independent sources suggest that we overestimated the forest cover in the older Historical Imagery, especially during 1984-2000 (supplement, part D). For instance, these sources indicate that the large majority (80%) of forests converted to oil palm were (severely) logged before land clearing [7,41]. Our overestimation is likely due to Google Earth replacing the clouds/gaps/striping in (often older) imagery to improve “the contrast, lighting, and consistency” [42] of its Historical Imagery.

**Figure 3.** Land use changes in all samples (l), Kalimantan (m) and Sumatra (r) between 1984-2016.

The oil palm expansion differs substantially between Kalimantan and Sumatra, with some oil palm already planted before 1984 in Kalimantan while oil palm emerged after 1992 in Sumatra. Also, the fraction of other land uses is higher while the fraction of lightly degraded forest is lower in Kalimantan. And where Kalimantan shows a gradual decrease in expansion, Sumatra shows a rapid increase between 2008-2016. Clearly, both islands have different dynamics related to forest degradation, deforestation and oil palm expansion.

With producing more than half of the 2019 RSPO certified palm oil [43], Indonesia leads in deforestation-free and responsible oil palm cultivation. Conversely, the demand for the responsible production of oil palm (ISPO and RSPO) significantly lags behind the production, with only half of the certified sustainable palm oil (RSPO) produced being traded as such [6].

**Figure 4.** Sustainability of management practices of forest (green), agriculture (yellow) and oil palm (l) and their impacts on SDG12 (r).

The impacts of oil palm cultivation on SDG15 were negligible in Kalimantan, with a slight decrease linked to land clearing during 1992-2008 and recovery during 2008-2016. The impacts in Sumatra are more distinct, with little and decreasing forest equivalence in 1984-1992 and further decrease due to oil palm cultivation in 1992-2008. However, the 2008-2016 recovery of forest equivalence is notable and suggests that oil palm cultivation can be a viable option for the rehabilitation of degraded lands.

**Figure 5.** 1984-2016 forest equivalence for oil palm expansion in Kalimantan (l) and Sumatra (r).
Google Earth’s Historical Imagery is a handy tool for rapid assessments of forest degradation and deforestation. But it requires in-depth expertise of remote sensing imagery and triangulation against the independent sources to avoid fallacious arguments (like ‘cloud shadows equal intact forest’). Within their proper context, they visualize what the science concludes: about half of Indonesia’s oil palm cultivation was degraded(!) forest in 1984 but local conditions vary for each area/island. In the wrong hands, Historical Imagery is easily abused to create false narratives such as the gaffe that “almost intact tropical forests were depleted in very recent times (<30 years)” for oil palm cultivation [4].

Indonesia follows the rule of law in managing development, including the expansion of oil palm plantations. The guidelines and procedures for acquiring additional land for plantations are also regulated by law [44]. Its multi-stakeholder collaboration – by government, private sector, and civil society– supports its drive towards responsible oil palm cultivation [45]. This has resulted in a National Action Plan (NAP) for Sustainable Palm Oil developed by all the stakeholders [46]: a comprehensive road map towards the improvement of sustainable palm oil production. This NAP is mandated mainly to 14 ministries/government agencies and 26 palm oil producing provinces and has become the main reference for government, private sector civil society and international development organizations in supporting the development of sustainable palm oil throughout 2019-2024. Furthermore, Indonesia very active in promoting oil palm through joint research, promotion, diplomacy and litigation.

4. Conclusions
The expansion of oil palm cultivation has caused adverse impacts on Indonesia’s ecosystems and communities. It is indeed linked to the conversion of degraded forests, biodiversity loss, disturbances to environmental services and livelihood changes. The Sustainable Development Goals provide the framework to assess these impacts holistically and objectively, without the traditional bias on environmental or social impacts.

Oil palm cultivation negatively impacts SDG15 in the short term (< 8 years), partially due to the land clearing and planting of oil palms. However, this negative impact is offset in the longer term (> 8 years) by the semi-permanent canopy layer and consequent increase in biodiversity in oil palm estates. The impacts of oil palm cultivation on SDG15 are even more pronounced, with little or no short-time impacts and significant positive impacts in the long term.

Forest degradation in Indonesia is a process that spans decades – not years – and is linked to a quandary of international commodities. Oversimplifying this process to ‘deforestation’ by a single commodity (like palm oil) ignores the vastness of this quandary. It also results in continuous “activism” that shifts from one commodity to another. A more holistic approach is needed to address this issue in effective and decisive ways. As such, the weakest link in the journey towards responsible management of oil palm is not the unwillingness of governments and/or growers in the tropics but the collective incredulity of consumers, fuelled by false narratives on social media.

If cultivated and consumed sustainably, palm oil plays an important role in the growing global demand for vegetable oil. Forest degradation and deforestation for oil palm cultivation have reduced significantly in Indonesia. Hence, cultivating oil palm using the mandatory and voluntary standards developed for it allows it to contribute to the prosperity of all stakeholders as well as safeguard the social and environmental values of the lands it is cultivated on.

The supplementary materials with this article include (a) the supply-base samples, (b) the google earth historical imagery 1984/1992/2000/2008/2016, (c) visual assessment of land cover 1984/1992/2000/2008/2016 and (d) the land cover 1984/1992/2000/2008/2016 from independent sources.

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