European Association of Remote Sensing Companies

Sentinels Benefits Study (SeBS)

A Case Study

Deforestation Monitoring for Sustainable Palm Oil Production

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Setting the Scene

Entering the last day of COP26, the latest gathering of nations with the aim to agree on a common way forward in our response to climate change, Elisabeth feels exhausted. Being a journalist specialised in climate matters, she had to follow numerous sessions where global leaders, scientists, representatives of NGOs, activists and industrial actors presented their take on what needs to be done and how. Much like this complex mix of ideas, political struggles and endless debates, Elisabeth feels her thoughts after this intense period are anything but clear. Her emotions are mixed up too. Browsing through her notes, the many headlines that made print over the past weeks and the many twitter threads she has been following, she is looking to distil all that was discussed and extract a glimmer of hope. It seems that the world may still have a chance, albeit the window of opportunity is vanishingly small. Indeed, the pledges that were made to stay on track with the 1.5C goal, leave a bittersweet taste for Elisabeth. "Pledges are important, but what about action" she asked herself aloud as she started browsing through the less prominent sessions of COP26. And it is precisely there, that she bumps into a seemingly small story which has now fully caught her attention. "Towards deforestation-free supply chains of agricultural commodities with some help from above"! As it turns out, deforestation contributes about 12% of annual global greenhouse gas (GHG) emissions, making it a major contributor to climate change. A significant part of this is associated with palm oil production; in fact, as the story reads, this is the major cause for deforestation in the two biggest producers in the world Indonesia and Malaysia. Elisabeth has covered this subject before! She remembers of consumer boycotts and protests together with several activists in her earlier years. So, what has changed now she wonders. As she reads on, Elisabeth finds out that major companies such as Bunge, Wilmar, Unilever and others are partnering with innovative companies such as Satelligence who provide deforestation monitoring solutions using Copernicus Sentinel satellite data. This helps agricultural commodity traders to monitor their palm oil supply chains and ensure deforestation free products, a requirement introduced both by regulation and consumer awareness! As Elisabeth reads on, she feels this cloud of confusion that overtook her earlier to disperse. "Now that is a tangible case of action!" she thinks. By now Elisabeth is devouring the information in this story; Satelligence produces alerts using Copernicus Sentinel data helping Bunge to quickly identify suspicious activities and efficiently investigate. By using such services more and more every year, the palm oil traders are getting closer to achieving sustainability commitments, benefitting the environment, protecting biodiversity and enjoying themselves significant financial benefits in relation to their investors and their reputation. "Talk about a win-win-win situation", Elisabeth shouts out. "But we need so many more of those, to truly turn the tide of climate change"!!!

Whilst the character in this story is entirely fictional, the situation is inspired by real events based on our knowledge gained through the case interviews.

Executive Summary

This case looks at how Sentinel data is being used to monitor for deforestation activities associated with palm oil production. The scope of this case is particularly large given the global coverage of palm oil plantations and the use of the service in this case across various countries.

This case revolves around the palm oil industry, an industry that is extremely lucrative but can often be associated with negative connotations and linked to environmentally damaging practices. These negative associations are not unfounded, in fact, by 2016, it has been estimated that almost 11 million hectares of forest has been lost to oil palm plantations worldwide, with over 80% of this deforestation due to palm oil plantations occurring in Indonesia and Malaysia. The establishment of palm oil plantations has also been a major issue for endangered wildlife such as orangutans and tigers in Sumatra. By consuming the habitats of the orangutan and Sumatran tiger (both critically endangered species) as well as numerous smaller animals, palm oil plantations are threatening biodiversity. Oil palms also have less than 20% as much above-ground biomass as rainforest trees, which means they have a lower capacity to absorb carbon dioxide from the atmosphere. That effect is exacerbated for the estimated one-third of Indonesian and Malaysian plantations located on waterlogged carbon-rich peaty soils. Draining such soils, which is necessary for the oil palms to grow, exposes the peat to oxygen, causing it to decompose and release huge quantities of carbon dioxide into the atmosphere. Action had to be taken to "turn the tide" in the fight against the harmful effects of irresponsible palm oil cultivation.

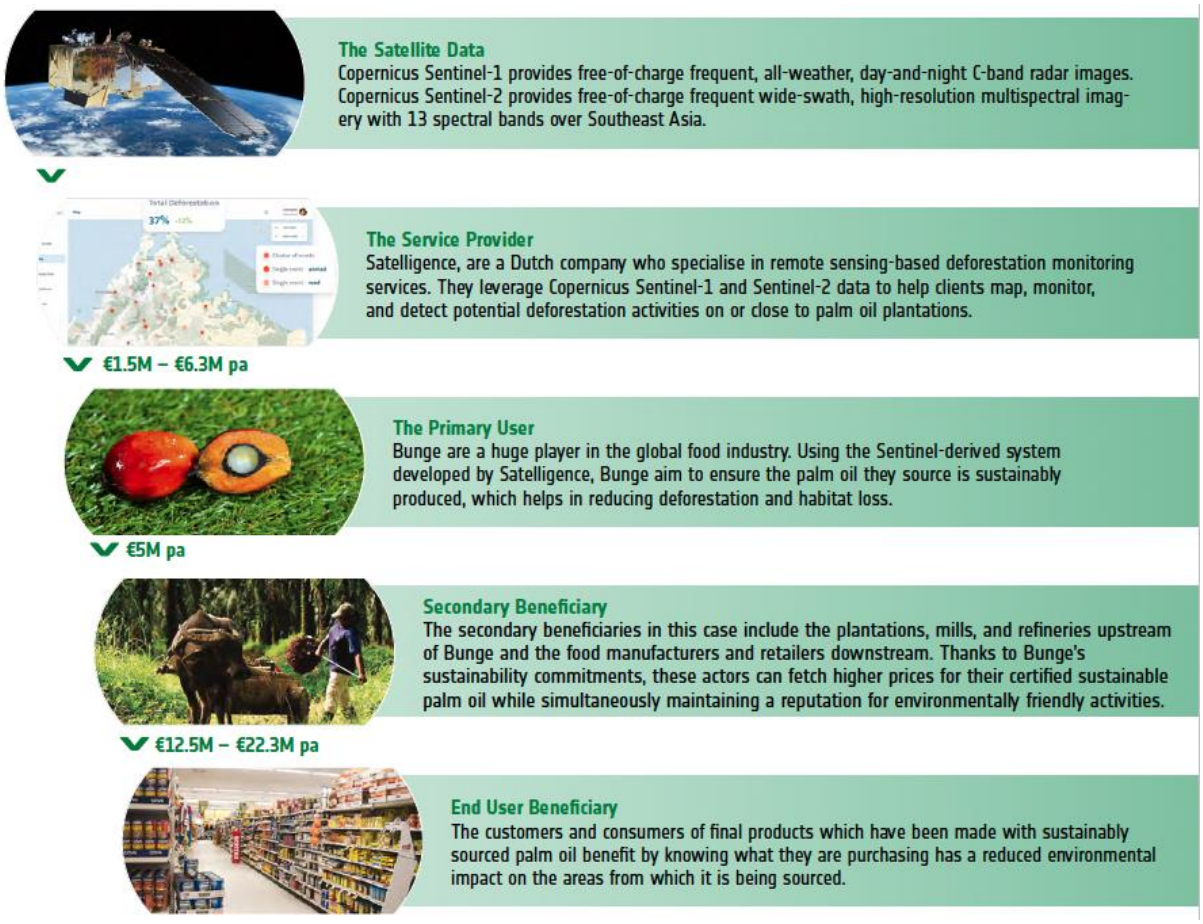
Satelligence, a Dutch remote sensing company have developed services using Sentinel-1 and Sentinel-2 data which can detect and monitor deforestation activities associated with the production of palm oil. In this case, Satelligence are helping Bunge, a huge player in the food industry to ensure the palm oil they source from Malaysia and Indonesia is coming from reputable sources and is not contributing to deforestation, habitat loss and climate change. If deforestation is detected and linked to a plantation or mill, Bunge can take appropriate action to help stop deforestation, helping to bolster the sustainability of their supply. The food products Bunge produce are then passed on to manufacturers and customers, meaning the ecologically friendly benefits are passed right down the value chain.

The economic benefits quantified in this case range from €19 million to €33.6 million (all figures explained in Chapter 5) and are derived from revenues accrued by Satelligence, access to favourable interest rates on sustainability-linked loans for Bunge and premium pricing for certified deforestation-free palm oil for producers. Despite these already large benefits, there are undoubtedly many other economic benefits manifested in each tier of the value chain that have not been quantified within this report due to the many unknowns and complexity involved in performing this analysis. For example, in tier 2 our economic analysis suggested that Bunge's corporate reputation could be as valuable as €3.4 billion. Bunge's use of Satelligence's service certainly helps in maintaining this reputation, but to assign a percentage of this figure to the use of a Sentinel-powered service would require several assumptions and ultimately would be quite an

uncertain figure. Nevertheless, the size of the concrete and quantifiable economic benefits speak for themselves.

Possibly the greatest benefits manifested in this case are to do with environmental sustainability. Bunge's use of Satelligence's service helps in the detection of deforestation, allowing actors to make informed decisions to counteract it. This, in turn, aids in the protection of natural habitats, the minimisation of peatland conversion and lowers the contribution of palm oil cultivation to climate change. This case showed such positive contributions to environmental sustainability that the benefits are experienced across every tier of the value chain analysed.

The benefits within each tier of the value chain are shown in the graphic below.



1 Introduction & Scope

1.1 The Context of this study

The analysis of the case study *'Deforestation Monitoring Worldwide"* is carried out in the context of the 'The Sentinel Economic Benefits Study' (SeBS). This 4-year study is looking to develop cases showing how EO-derived products based on data generated by one or more Sentinel satellites deliver value to society and citizens. The Sentinel satellites form a crucial part of EU's Copernicus Programme, providing space-based observations on a full, free and open basis. Data coming from the Sentinels – together with other data collected by contributing missions and ground, sea or airborne instruments – is used to support key economic or societal areas such as agriculture, insurance, disaster management, climate change monitoring, etc. Sentinel data are thus a key component of the Copernicus Services, and a crucial source used by companies to deliver products and services helping different users across the Globe.

1.2 What is the case all about?

The subjects of deforestation and ecological conservation continue to be amongst the most pressing issues of our time. We are all familiar with the harrowing images of orangutans in Borneo or the indigenous peoples of the Amazon being forced out of their homes to make way for property developments or enormous industrial farms. The devastation of ecological systems is endangering countless species and rapidly driving our most vulnerable flora and fauna to extinction. Furthermore, when forests are cleared or burned to make way for infrastructure, industry and monocultural practices, CO_2 is released into the atmosphere, where it directly contributes to rising global temperatures and climate change. Forests still cover about 30% of the world's land area, but are disappearing at a truly alarming rate. Between 1990 and 2016, the world lost 1.3 million square kilometres of forest, according to the World Bank—an area larger than South Africa[1].

The palm oil industry continues to be one of the main contributors to deforestation in some of the world's most biodiverse regions such as the tropical rainforests of Southeast Asia, Sub-Saharan Africa and South America. Palm oil is found in close to 50% of packaged products in supermarkets, from chocolate, to shampoo, to doughnuts and even lipstick. It also acts as a constituent in many animal feeds and even biofuels in certain parts of the world[2]. Due to its versatility and low price its market demand is constant and high, which incentivises the unsustainable and rapidly growing industrial practice of clearing land to make way for new palm oil plantations. With this in mind, pressure is mounting on the international community and national governments to step up and take action to minimise harmful palm oil cultivation practices and increase the sustainability of this sector. Methods of monitoring the deforestation caused as a result of palm oil plantations, as well as the tracing of palm oil's origin in the supply chain are constantly being advanced.

[1] https://www.nationalgeographic.com/environment/global-warming/deforestation/

[2] https://www.wwf.org.uk/updates/8-things-know-about-palm-oil

This case studies how Copernicus Sentinel data is being used to help Bunge, a major food company, to ensure that the palm oil used in their supply chain is sustainably sourced. Satelligence, a Dutch start-up company, utilise Sentinel imagery to provide deforestation and supply chain monitoring services to Bunge. Satelligence's service allows for the origin of all palm oil bought by Bunge in Southeast Asia to be traced ensuring that its production is "deforestation-free".

In this report, you will discover both the story and the rigorous analysis around the benefits experienced by different value chain actors in this case. The analysis relies on clear and openly presented assumptions which have been shaped with the help of the stakeholders we interviewed (see 1.5 below). However, we encourage any reader to contact us if they think the assumptions are unreasonable for any reason through emails to Lefteris Mamais (lef@earsc.org).

1.3 How does this case relate to others?

This case is one of the portfolio cases being developed and analysed within the frame of the SeBS project. It is the second case that deals with forestry applications, with an earlier case looking at forestry management in Sweden, however, this is the first which looks at the detection and monitoring of deforestation specifically. It is also the first long case that looks at a worldwide application which is not just limited to one country.

In terms of the satellite data, Sentinel-1 and Sentinel-2 have featured in many previous reports, especially linked to the likes of agriculture, food production and environmental monitoring.

1.4 More About the Study

Each case study analysed in SEBS, focuses on products and services which use data coming from Sentinel satellites, measuring the impact of that product or service throughout the value chain. The starting point is the primary user of the satellite data, followed by a step-by-step analysis whereby the operations of beneficiaries in each subsequent link of the value chain are analysed, all the way down to citizens and society.

In this process, the main aim is to understand and demonstrate the value which is generated using satellite-based Earth Observations (EO) and particularly the data coming from the Copernicus Sentinel satellites. Each case study thus underlines the causal relationship between the use of Copernicus Sentinel satellite data and benefits resulting from their use, including increased productivity, more efficient and environmentally friendly operations, economic gains and improved quality of life, among others. The evaluated and demonstrated benefits can be used by:

- **Decision makers**: Having access to a portfolio of concrete cases where the benefits from the operational use of Sentinel data in decision making are clearly articulated, helps decision makers not only to justify future investments but also to direct them towards areas that most matter in their country or organisation.
- **Users:** Moving beyond a vague idea of how EO services can support more effective operations requires a concrete understanding of the benefits they can actually bring in similar cases. In this regard, it is both numbers and stories that can resonate with users and attract them to explore further or deeper uses of EO in their operational activities.

- **Service providers:** Solid argumentation around the economic and environmental benefits stemming from the use of EO, coupled with powerful storytelling, can become an effective marketing tool for service providers seeking to promote their solutions and for EARSC to promote the sector.

In the framework of this project, 20 case studies will be developed with reports to be published on each one. The study has started in March 2017 and will end in mid-2022.

1.5 Acknowledgements

We wish to thank the following persons for their time spent talking with us. In particular;

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Arjen Vrielink – Satelligence

Tijs Lips – Bunge

Ben Vreeburg – Bunge

***Please note:** All economic analysis performed in this report was undertaken by the authors alone. It is based on publicly available data and was not confirmed by Satelligence or Bunge. Any statements in the document are based on the authors' interpretation of publicly available data and some inputs provided during interviews and final fact check reviews from both Satelligence and Bunge. Satelligence or Bunge should not be considered co-writers or sponsors of this document.*

2 Palm Oil

The heart of this story revolves around the palm oil industry, therefore it is important to understand what palm oil is, its uses, its production and most importantly its controversies. The following sections address these topics.

2.1 What is palm oil and why is it so popular?

Palm oil is an edible oil derived from the fruit of the oil palm tree, whose scientific name is "*Elaeis guineensis*". Although native to Africa, oil palm trees were brought to Southeast Asia around 100 years ago and were originally intended to be used only as ornamental tree crops. As the practicality and versatility of their oil became apparent, the planting and cultivation of oil palm trees increased rapidly. Now, Southeast Asia and in particular Indonesia and Malaysia make up over 85% of global supply. Another 42 countries, primarily in tropical regions, make up the rest of the global palm oil supply.[3]

Figure 2-1: A palm oil tree plantation with the red fruits visible

The oil palm tree can provide two types of oil; "crude palm oil" is made from the pulp of the deep-red fruits of the tree, while "palm kernel oil" comes from crushing the kernel, or the stone in the middle of the fruit. Crude palm oil is generally red or orange in colour while palm kernel oil is much

[3] https://www.wwf.org.uk/updates/8-things-know-about-palm-oil

clearer and often light yellow or clear in appearance. The picture below shows the opaque red/orange crude palm oil on the left with oil palm fruits in front. On the right is the clear palm kernel oil made from the kernels of the fruit (also shown in front). Although both oils come from the same plant, they generally have different uses; crude palm oil and its derived products are typically used to make edible goods, while palm kernel oil is primarily used for non-edible products such as soaps, moisturisers and cosmetics. However, due to its stability at high temperatures, palm kernel oil is also often used as a cheap option for commercial cooking and deep frying.

Figure 2-2: Visual comparison of crude palm oil and palm kernel oil

Palm oil has become popular in a multitude of modern-day products for two main reasons:

1. It is **extremely** versatile and has numerous attributes which allow palm oil to lend itself to a plethora of applications. To begin, palm oil is highly resistant to oxidation, so when added to food products it can give them a longer shelf-life. This characteristic alone is seen as very attractive and useful to the food industry as it allows food processors and producers to build reserves of produce which can be sold at convenient times rather than relying on immediate sales. It is semi-solid at room temperature and therefore can be used to help spreads and pastes maintain their viscosity and texture. As previously mentioned, it is very stable at high temperatures and therefore helps to give fried foods a crispy texture. Also, depending on which derived product is used, it can also be colourless and odourless and therefore doesn't change the appearance or smell of food when included in it. Due to its many adaptable and useful qualities, palm oil is found in a vast amount of food and retail

products including pizza dough, instant noodles, ice cream, shampoo, chocolate, bread, margarine, animal feed, soap and biodiesel to name but a few.

2. Oil palm trees are **one of the most efficient oil producing crops** in existence. They can produce more oil per land area than any other edible oil producing plant. For example, soy produces around 0.4 tonnes of oil/hectare/year and coconuts, sunflowers and rapeseed all produce around 0.7 tonnes of oil/hectare/year. Compare this to oil palm, which produces roughly 3.3 tonnes of oil/hectare/year, meaning that depending on which crop you compare it to, oil palm trees need 4 to 10 times less land area to produce an equivalent amount of oil.[3] This implies that very large quantities of palm oil can be produced for much cheaper than other similar oils as a result of the lower land usage requirement. Palm oil is therefore seen by the food and produce industry as a cheaper and useful alternative to many other constituent oils, which drives palm oil's constant high demand.

Given the fact that palm oil is ubiquitous in our supply chains, it begs the question; "Is palm oil bad for us?" It is true that palm oil is high in saturated fat, and excess consumption is something to be avoided by people with cardiovascular issues. However, a study published in the World Journal of Cardiology concluded that "*Palm oil consumed as a dietary fat as a part of a healthy balanced diet does not have incremental risk for cardiovascular disease. Little or no additional benefit will be obtained by replacing it with other oils rich in mono or polyunsaturated fatty acids.*"[4] In fact, palm oil is a good source of tocotrienols, a type of vitamin E which is an antioxidant that provides protection to your cells and may reduce your risk of certain health problems such as heart disease and cancer.[5] Therefore, the controversies surrounding palm oil primarily stem from the associated unsustainable and harmful planting, cultivation and processing practices and not its effect on our diets and health.

2.2 Overview of the palm oil industry

The global palm oil market demand was estimated at 74.6 million tonnes in 2019.[6] The worldwide production of palm oil has been growing steadily for the past fifty years and has rapidly accelerated in recent decades. Between 1995 and 2015 the global annual production quadrupled, from 15.2 million tonnes to 62.6 million tonnes. The global production is expected to almost quadruple again in the coming years, reaching an estimated 240 million tonnes of global annual production by 2050.[7] Palm oil has become so unavoidable and such a staple of both our diets and lifestyles that it has been estimated everybody on earth consumes an average of 8kg of palm oil annually.[7]

As previously stated, the vast majority of the global supply (around 85%) is produced in only two countries in Southeast Asia; Malaysia and Indonesia. Palm oil is both Malaysia and Indonesia's main agricultural export, generating 5% and 10% of their entire exports respectively.[8] It is also estimated that the palm oil sector makes up about 3.8% and 1.8% of GDP in Malaysia and Indonesia,

[4] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4365303/

[5] https://www.independent.co.uk/life-style/palm-oil-health-impact-environment-animals-deforestation-heart-a8505521.html

[6] https://www.grandviewresearch.com/industry-analysis/palm-oil-market

[7] https://www.theguardian.com/news/2019/feb/19/palm-oil-ingredient-biscuits-shampoo-environmental

[8] https://epthinktank.eu/2018/02/19/palm-oil-economic-and-environmental-impacts/

respectively.[9] The palm oil industry provides direct employment for around 720,000 small farmers and labourers in Malaysia, and almost 4 million in Indonesia. It is estimated that a further 11 million people in the two countries combined are indirectly dependent on the palm oil industry. Almost all oil palm plantations and their associated jobs are found in remote rural areas of the two countries, where alternative employment is scarce, therefore the industry helps to support rural development and employment in these economically deprived areas.[8] It is no wonder why palm oil has such a hold on the economies of the main producing countries; put simply, it is one of the most profitable land uses possible in these parts of the world. For example, In Indonesia, the average income in a complete financial year of an oil palm plantation is up to $2,500 (USD) per hectare, compared to only $250 for a rice plantation.[10] As a result of this quick economic win, its cultivation is an easy way to drive rapid economic growth and contribute to the alleviation of rural poverty in these regions.

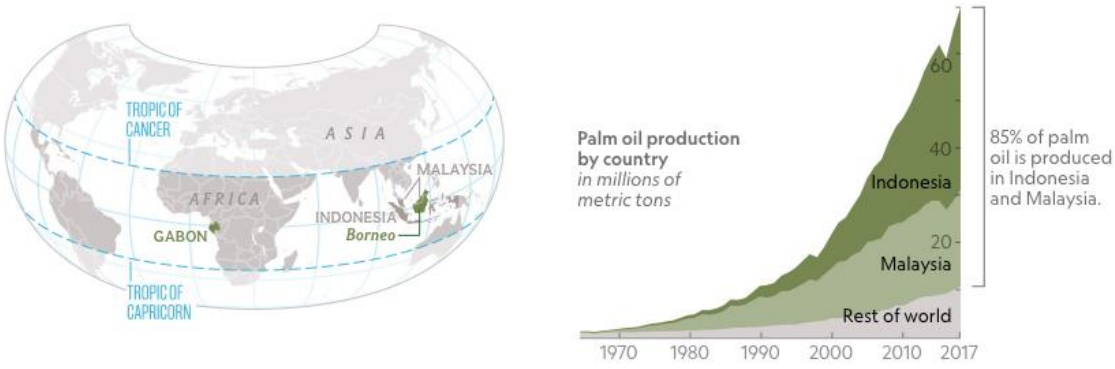


Figure 2-3: Overview of palm oil producing regions and growth over time[11]

2.2.1 Palm oil cultivation

Oil palm is a humid tropical crop and thrives in the areas where temperature ranges from 22°C to 24°C (minimum) and 20°C to 33°C (maximum), there are 5 to 6 hours of bright sunshine per day and 80% average humidity, meaning tropical regions close to the equator are perfect for its cultivation.[12] Oil palms are generally ready for harvesting within 2.5 to 3 years after the plantation. Determining harvesting time is very important in oil palm cultivation as it greatly impacts the quality and quantity of oil. Harvesting is carried out when the fruits on palm turn into yellowish – orange colour and have 5 to 8 fruits drop from a bunch on their own.[12]

[9] https://www.cifor.org/publications/pdf_files/WPapers/WP220Pacheco.pdf
[10] https://www.spott.org/palm-oil-resource-archive/impacts/economic/
[11] https://www.nationalgeographic.com/magazine/2018/12/palm-oil-products-borneo-africa-environment-impact/
[12] https://www.plantationsinternational.com/palm-oil/

2.2.2 The palm oil processing chain

For the purposes of this study, it is important to understand the palm oil processing chain as it gives an appreciation of the labour involved but also the key points at which the sustainability of the value chain can be monitored.

Overall, the crude palm oil extraction process is a relatively simple one. The general steps involve the collection of the fresh fruit bunches from the various growers and plantations, sterilizing and threshing of the bunches to remove the oil palm fruit, and then mashing the fruit and pressing out the crude palm oil. The crude oil is further treated to purify and dry it for storage and export.[13] Extraction of oil from the palm kernels is generally separate from crude palm oil extraction and will often be carried out in mills that process other oilseeds. The stages in this process comprise grinding the kernels into small particles, heating (cooking), and extracting the oil using an oilseed expeller or petroleum-derived solvent. The oil then requires clarification in a filter press or by sedimentation.[13] The diagram below shows the crude palm oil and nut separation process flow diagram.

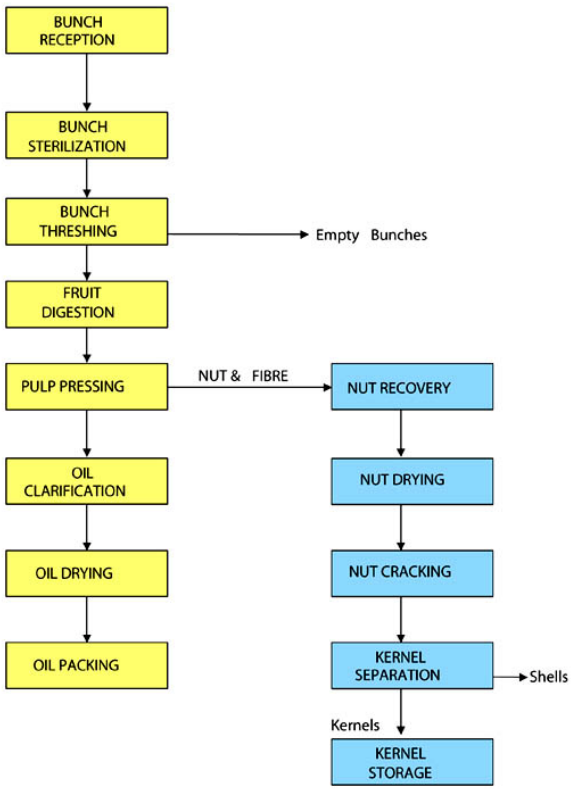


Figure 2-4: High level crude palm oil processing flow diagram

The transportation of fresh palm oil fruit bunches is generally limited to a radius of 50km –100km due to the rapid deterioration of the fruit quality after harvesting. Once the fresh fruit bunch is

[13] http://www.fao.org/3/y4355e/y4355e04.htm

milled, the resulting crude palm oil is transported to the refineries for further fractionation, which are often located in or close to main export ports. In Malaysia, licenses for the development and operation of palm oil mills are issued to a company only if it possesses its own plantation of at least 4000 hectares or has access to plantations belonging to its group or subsidiary companies. In Indonesia, similar rules applied in the past – currently, however, only independent mills without their own plantations, and whose only source of fresh fruit bunches is from independent growers, are permitted. This has stimulated the growth of independent mills in established oil palm areas.[9]

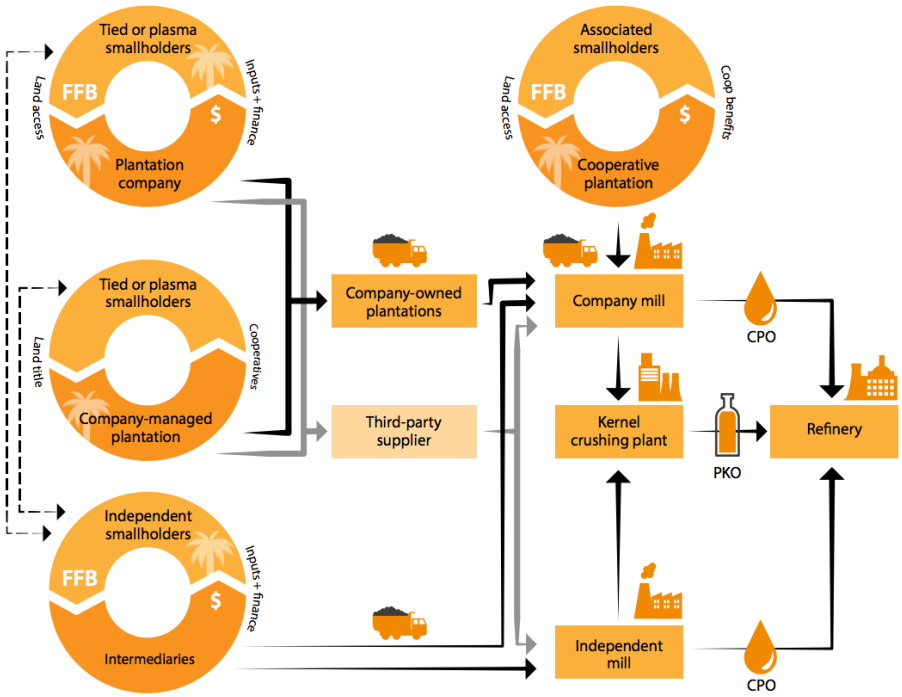


Figure 2-5: Simplified diagram showing the palm oil milling and crushing value chain[14]

2.2.3 The global trade flows of palm oil

The majority of palm oil from Malaysia and Indonesia is exported. Key export markets include India, China and Europe. Regardless of origin, the main importing countries are India (16.5%), China (8.89%), Pakistan (6.3%), The Netherlands (5.81%), and Spain (3.9%). It is clear that Asia is the main market, absorbing almost 50% of total imported palm oil and its derivatives, followed by Europe which makes up almost one third. In 2014, about 45% of total European imports of palm oil were consumed in biodiesel for the transportation sector.[9] The tree map below shows the main global importers of palm oil in 2018.

[14] https://www.researchgate.net/figure/Simplified-palm-oil-value-chain-Authors-elaboration-taking-elements-from-Suharno-et_fig4_315477419

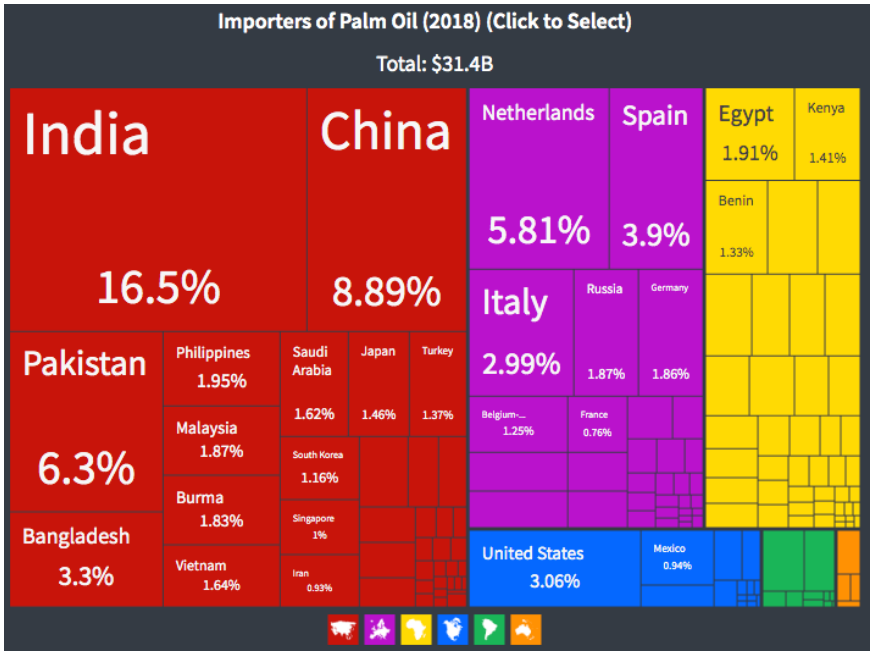


Figure 2-6: Global importers of palm oil[15]

The palm oil processing industry is well developed in Malaysia, where companies maintain higher comparative advantage based on their efficiency. Indonesian companies have been able to slowly expand their palm oil refining capacity over time, thanks to government incentives aimed at capturing more of the added value from manufacturing in the country. Palm oil processors and traders supply to what can be described as a highly diverse collection of end-users. These include a wide range of consumer goods manufacturers and retailers delivering a range of products in the food, chemical, pharmaceutical and cosmetic industries. While much of the processing and refining of crude palm oil and palm kernel oil takes place in Indonesia, Malaysia and Singapore, most manufacturing takes place in the countries of consumption and in China, where transnational corporations manufacture products for consumers around the world.[9]

The global palm oil sector is dominated by a handful of conglomerates involved in production, processing and trade (i.e. Wilmar, Musim Mas, GAR, Cargill and Asian Agri in Indonesia and Sime Darby and FELDA in Malaysia). These groups source palm oil from their own plantations as well as from a large number of third-party suppliers.[9]

[15] https://oec.world/en/profile/hs92/31511/

2.3 Harmful impacts of palm oil production

The main issue with the palm oil industry is its harmful effect on our planet. The rampant cultivation of palm oil leads to deforestation, habitat loss, reductions in biodiversity and carbon emissions.

2.3.1 Deforestation

By 2016, it has been estimated that almost 11 million hectares of forest has been lost to oil palm plantations worldwide[16], with over 80% of this deforestation due to palm oil plantations occurring in Indonesia and Malaysia. The United Nations Environment Programme indicated back in 2007 that oil palm plantations are the leading cause of rainforest destruction in both Malaysia and Indonesia. Another study by Princeton reported that between 1990 and 2005, up to 60% of palm oil expansion occurred at the expense of tropical rain forest.[17]

However, a promising trend has been emerging in recent years. In its 2021 report on deforestation, **the WWF reported a reducing trend in forests being lost to palm oil plantations in both Indonesia and Malaysia. The World Resources Institute also reported similar findings,** citing tighter regulations and enforcement of certification schemes as well as corporate deforestation commitments as some reasons for this positive trend.[18]

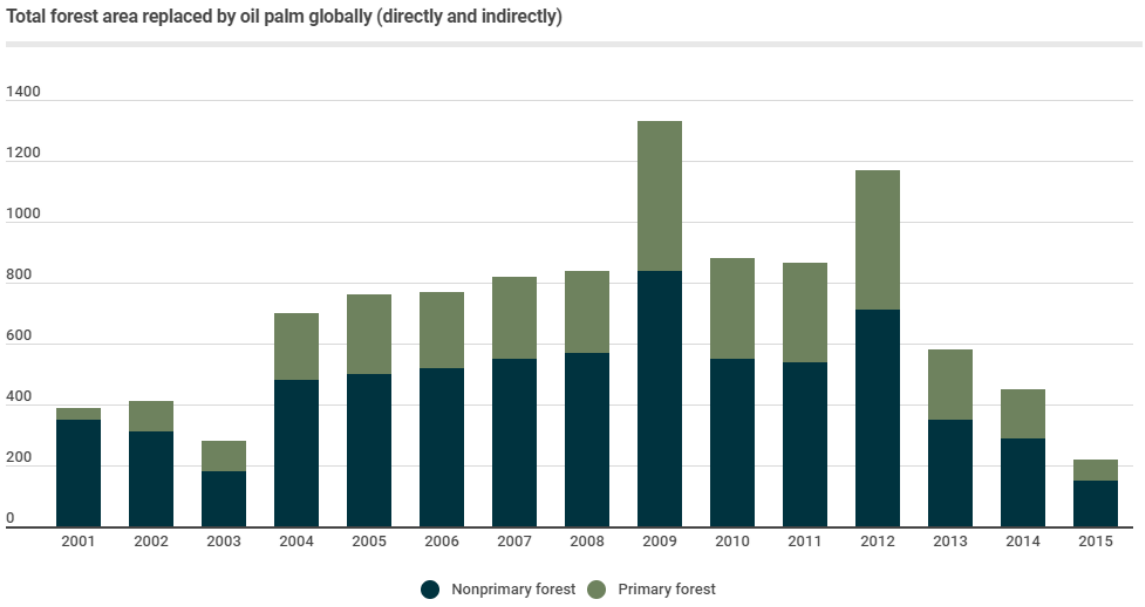


Figure 2-7: Decline in deforestation due to palm oil plantations in recent years[18]

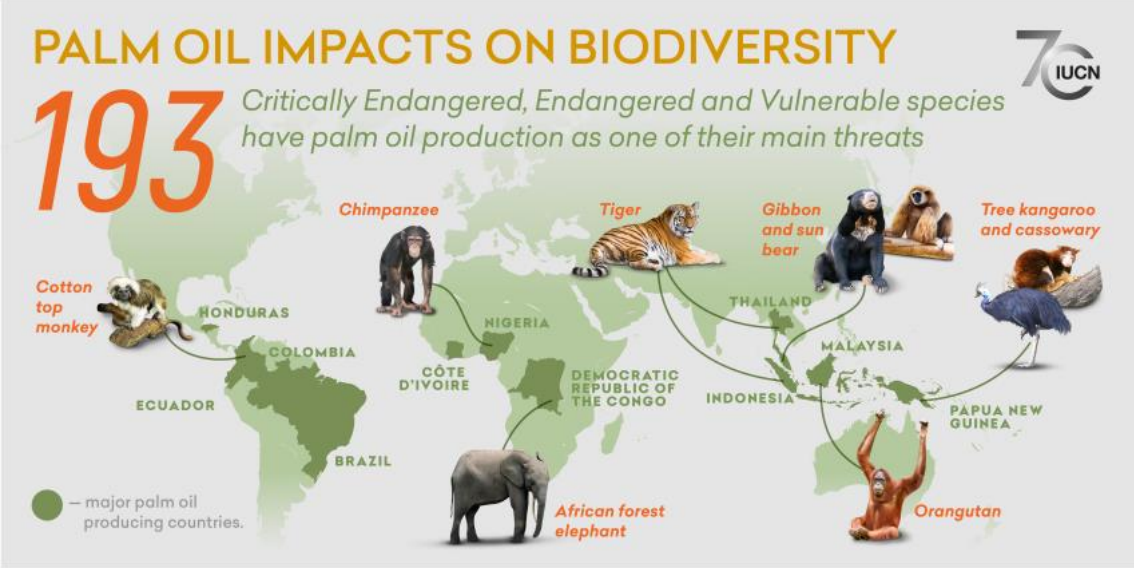
16 https://www.conservation.org/blog/what-you-need-to-know-about-palm-oil-in-5-charts

17 https://orangutan.org/rainforest/the-effects-of-palm-oil/

18 https://palmoilalliance.eu/palm-oil-deforestation/

2.3.2 Habitat and biodiversity loss

The establishment of palm oil plantations has been a major issue, for endangered wildlife such as orangutans and tigers in Sumatra. Compared to rainforests, palm oil plantations support only one fifth as many animal species. By consuming the habitats of the orangutan and Sumatran tiger (both critically endangered species) as well as numerous smaller animals, palm oil plantations threaten biodiversity. According to the IUCN Red List of Threatened Species, palm oil plantations are threatening at least 193 endangered species worldwide such as the African forest elephant in the Congo and the cotton top monkey in South America.



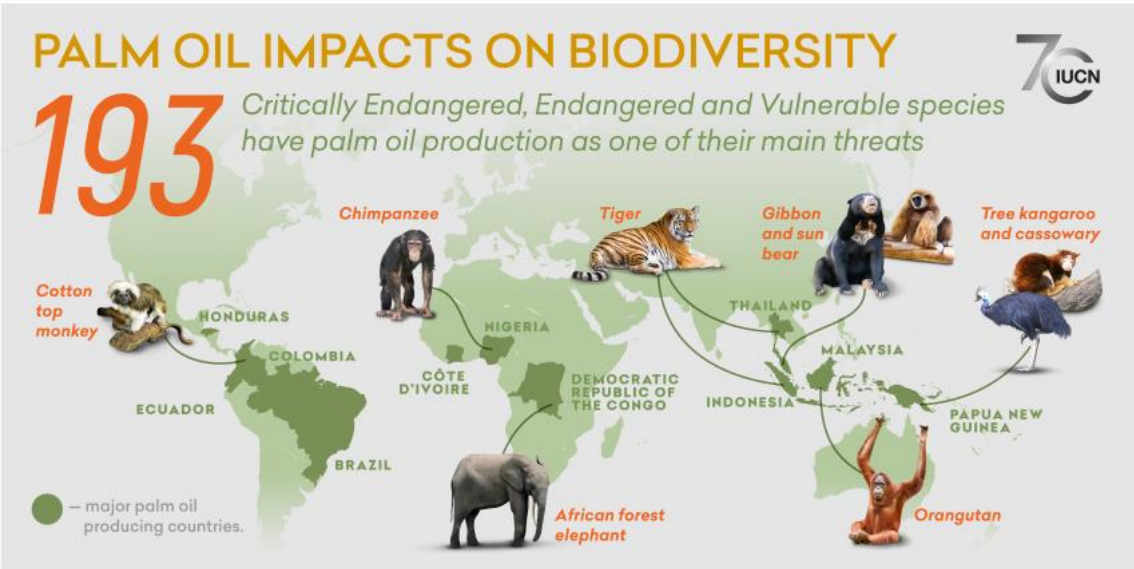


Figure 2-8: Critically endangered species are being affected by palm oil[19]

2.3.3 Carbon emissions

Oil palms have less than 20% as much above-ground biomass as rainforest trees, which means they have a lower capacity to absorb carbon dioxide from the atmosphere. That effect is exacerbated for the estimated one-third of Indonesian and Malaysian plantations located on waterlogged carbon-rich peaty soils. Draining such soils, which is necessary for the oil palms to grow, exposes the peat to oxygen, causing it to decompose and release huge quantities of carbon dioxide into the atmosphere. **Peat drainage in Southeast Asia, largely in order to clear land for oil palms, is estimated to cause the equivalent of 2% of global fossil fuel CO_2 emissions**.[8]

Forest fires are another (even bigger) contributor to climate change due to the amount of carbon released and are a recurrent environmental disaster in Southeast Asia, particularly in Indonesia. Such fires can occur naturally, but many are started deliberately, often by smallholders practicing "slash and burn" agriculture, but sometimes also by large plantation operators. In the dry season, fires can easily get out of control, destroying huge areas of forest. Around 20% of these fires can be directly attributed to palm oil. Moreover, given that drained peat soils burn easily, fires can spread even more fiercely as an indirect, yet compounding result of palm oil cultivation.[8]

2.4 What can be done to mitigate the palm oil industry's harmful impact?

There are many hurdles to overcome to change the ways of current practices in the palm oil industry. Below, some of the drivers for change are discussed.

2.4.1 Consumer awareness

Consumer awareness and social demand for sustainability in our food chains has become a powerful driver for change in the palm oil sector. A 2019 study by YouGov in the UK found consumer awareness of palm oil itself to be quite high at 77%, with 41% of people being aware of the harmful environmental impact it can have. This awareness was more than twice as high as any other vegetable oil considered.[20] Moreover, there is an ongoing macro trend in the food industry whereby consumers are becoming more and more aware of where their food is coming from and the sustainability of its production methods. In a study recently conducted by Forbes, they found that 65% of consumers look for products that can help them live a more sustainable and socially responsible life with 54% of respondents trying to purchase products or services from brands that take a stand on social or environmental issues.[21]

Consumer goods manufacturers and retailers in Western markets in particular have been key drivers in recent sustainability commitments related to palm oil. Major NGOs and advocacy groups

[19] https://www.iucn.org/resources/issues-briefs/palm-oil-and-biodiversity

[20] https://yougov.co.uk/topics/science/articles-reports/2019/01/04/journal-update-exploring-sustainable-palm-oil-ecol

[21] https://www.forbes.com/sites/jefffromm/2020/11/10/sustainable-food-trends-will-become-center-of-the-plate-with-modern-consumers/?sh=2f352e244fe6

have targeted consumer brands and reputations, such as Nestle, Unilever, Krispy Kreme and Dunkin' Donuts, to leverage change among their suppliers.[9] This positive trend, in which buyers are demanding responsible management of the food production chain, is helping to ensure producers remain vigilant and sustainable.

2.4.2 Regulation and certification

Pressure is also being placed on food and product producers to become more sustainable in relation to palm oil from a governmental and regulatory level. For example, in 2018 the European Parliament banned palm oil for biofuels, citing environmental concerns. In addition to this, many European countries, including large industrial nations such as Germany, France and Italy have committed to buying only sustainably produced and certified palm oil. To help importers in discerning truly sustainably produced palm oil and with the objective of promoting the growth and use of sustainable oil palm products through credible global standards and multi-stakeholder governance, in 2014 the Roundtable on Sustainable Palm Oil (RSPO) was established. The RSPO are a not-for-profit organisation based in Switzerland that unites stakeholders from the 7 sectors of the palm oil industry: oil palm producers, processors or traders, consumer goods manufacturers, retailers, banks/investors, and environmental and social non-governmental organisations (NGOs), to develop and implement global standards for sustainable palm oil. The RSPO has developed a set of environmental and social criteria which companies must comply with in order to produce Certified Sustainable Palm Oil (CSPO). When they are properly applied, these criteria can help to minimise the negative impact of palm oil cultivation on the environment and communities in palm oil-producing regions. The RSPO has more than 4,000 members worldwide who represent all links along the palm oil supply chain. They have committed to produce, source and/or use sustainable palm oil certified by the RSPO.[22]

2.4.3 Green financing

Another mechanism being used to incentivise actors in the food production value chain to adopt sustainable practices is through "responsible financing". Responsible financing refers to the practice of granting entities better access to financial mechanisms such as loans with more favourable interest rates in return for proving their operations or investments are maintaining or contributing to environmentally sustainable practices. For example, Bunge, a huge actor in the agri-food business closed its first sustainability-linked revolving credit facility (a loan), worth $1.75 billion USD in 2019. The new facility agreement links Bunge's interest rate to its performance on several sustainability targets, such as reducing greenhouse gas emissions by improving industrial efficiency, increasing traceability for main agricultural commodities and supporting increasing levels of adoption of sustainable practices across the wider soybean and palm oil supply chain.[23] Parallel to

[22] https://rspo.org/

[23] https://www.bunge.com/news/bunge-limited-closes-its-first-sustainability-linked-revolving-credit-facility

mandatory regulations being set by lawmakers and government institutions, financial incentives such as this are also making sustainability more economically efficient.

2.4.4 Industry response

Unlike the cocoa and coffee markets, which are dominated by a handful of retailers and manufacturers, the challenge with the palm oil industry is that the uptake of palm oil is highly fragmented. One of the biggest consumers is Unilever, which consumes around 4% of the world's supply of palm oil. This means that individual consumer goods manufacturers and retailers have limited influence and leverage on the supply chain and the sustainability standards of production. Imposing standards on producers is particularly challenging, as a large proportion of palm oil is manufactured and sold in India and China, countries whose consumers are generally more price sensitive and less concerned with sustainability. Instead, the palm oil supply chain forms bottle-necks at the refining and trading stages, as it is channelled through a relatively small group of processors and traders.[9] Nevertheless, as already discussed, the market incentives and regulatory measures do seem to be making an positive impact in some aspects related to palm oil sustainability, such as the reducing deforestation rates seen in the last 4 to 5 years.[18] There is, however, a long way to go to ensure all negative impacts associated with the production of palm oil are reduced and maintained at these levels in the future.

2.5 Informed decisions, coordinated actions and effective interventions

Given the well-founded concerns associated with the production and processing of palm oil, controls are required to ensure the palm oil is being produced sustainably, with minimal impact on habitats, biodiversity and forest biomass. Continual enforcement and maintenance of the regulations and incentives already discussed is necessary to make sure growers, processors and importers do not cut corners, exploit fragile ecosystems, or take advantage of vulnerable communities when conducting operations. Given the strong demand for palm oil, perverse incentives are a constant lure for actors in the supply chain to maximise profits to the detriment of natural habitats and the environment.

2.5.1 Collecting the necessary data

To enforce regulation around palm oil, data must be collected at many stages of the value chain. For example, one must understand who is producing and processing the palm oil, where plantations are situated and how they are operating, where they oil is being transported, who is buying and selling it and what, if any, negative externalities are materialising as a result, such as deforestation. Conventionally, this involved gathering many different types of data, from site inspection data, whereby inspectors would visit plantations or processing sites to ensure everything was above board, to supply chain and economic data, whereby accounting and financial records could be audited to make sure all actions within and across the supply chain were legitimate. Piecing this

data together allowed for certification schemes to discern between sustainably produced palm oil, and unsustainably produced palm oil.

2.5.2 Limitations of conventional methods

Given the enormity of the palm oil industry, collecting all the data required for regulation and certification using conventional methods had some major drawbacks, in particular the vast geographic coverage of the areas of the world in which palm oil can be cultivated makes it extremely difficult to monitor all plantations and processing plants. Thick jungle and secluded rural areas can easily hide illegal plantations and the deforestation associated with these operations can quite easily slip under the radar. Practically, manual inspections of sites cannot be done continuously for all areas and can therefore only catch a fraction of illegal or unsustainable operations given the finite human resources available. Moreover, measuring the impact of these unsustainable operations i.e., quantifying the amount of deforestation and habitat loss associated with palm oil production brought with it even more requirements for inspection.

All these limitations can – to a very large extent – be addressed by the use of satellite data. Therefore, a few years ago, Satelligence, an Earth observation company from The Netherlands began to develop monitoring systems which could help to remotely and continuously detect and monitor deforestation issues related the palm oil production anywhere in the world.

We will look into this service in the next chapter, followed by a thorough account of how it was used by the different actors (chapter 4) and the concrete value it brought (chapter 5).

3 The Use of Sentinel Data

3.1 How can satellites help with deforestation monitoring?

Remote sensing techniques are being increasingly used for the provision of timely and accurate data on several aspects related to forest monitoring and management. The combination of satellite imagery with meteorological data, biophysical modelling and statistical analyses allows the continuous monitoring of forested areas and the extraction of valuable information that can allow for the detection and monitoring of forest degradation, deforestation, illegal forest operations and movements related food commodity supply chain chains. In this context, the ability of satellites to gather information on tree and plant health as well as forest canopy coverage over large areas and with a high revisit frequency, is leveraged in multiple applications. These include forest biomass monitoring, forest inventory monitoring, forest vegetation health assessment, illegal logging monitoring, deforestation/forest degradation monitoring land cover analysis.

Before entering into the specifics of this case and the deforestation monitoring services implemented in Southeast Asia, it is important to understand how satellites can capture changes on the surface of the Earth giving rise to information that is extremely valuable to entities involved in the monitoring of forests.

Broadly speaking there are two main classes of Earth Observation satellites[24]:

- Those carrying **passive sensors** able to detect the sun's energy as it is reflected from the Earth's surface. These "optical" satellites are affected by cloud coverage (at it hinders solar radiation) and can only observe during daytime. Typically used sensors in this category are radiometers (incl. imaging and spectro-radiometers) and spectrometers.
- Those carrying **active sensors** capable of emitting their own energy (in the form of electromagnetic radiation) to illuminate the scene (and objects therein) they observe. Such satellites send a pulse of energy from the sensor to the object and then receive the radiation that is reflected or backscattered from that object. Typically used sensors in this category are radar, scatterometers and lidar. Satellites carrying such sensors – for example Synthetic Aperture Radar (SAR) satellites – are unaffected by cloud coverage.

[24] A nice overview of passive and active instruments on board earth observation satellites is provided in https://earthobservatory.nasa.gov/Features/RemoteSensing/remote_08.php

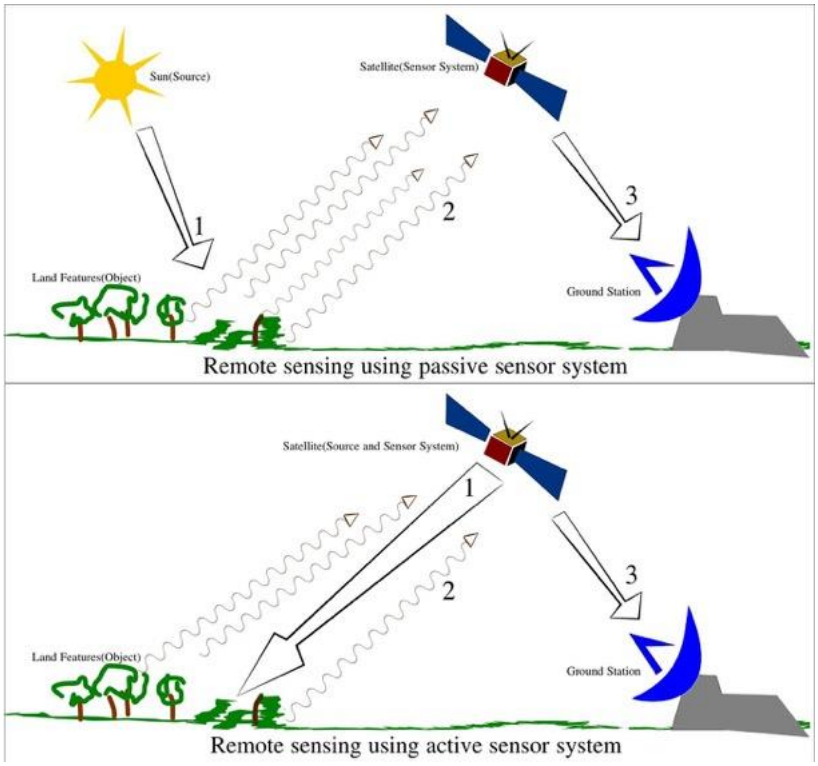


Figure 3-1: Illustration of passive versus active remote sensing[25]

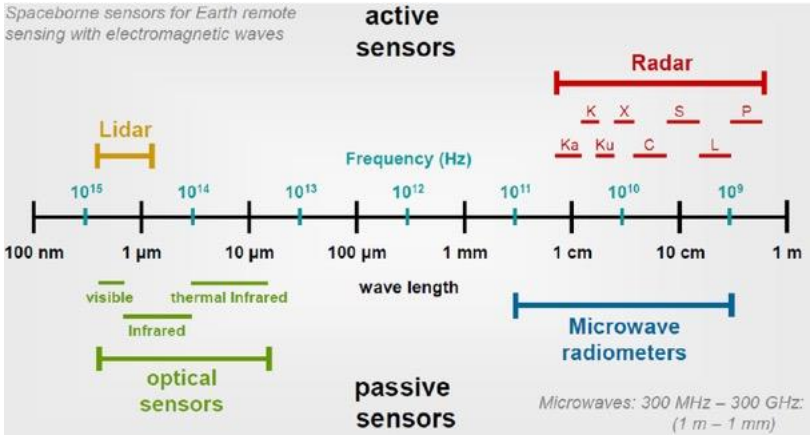


Figure 3-2: Active and passive sensors used for remote sensing[26]

As seen in Figure 3-1, active and passive sensors emit/collect electromagnetic signals of different wavelengths. In practice, different materials on the Earth's surface reflect electromagnetic waves in a different manner. These reflectance differences allow Earth Observation (EO) satellites to distinguish between grasslands, water surfaces, forests, buildings, etc. When more than two wavelengths are used, the separation among objects is even more evident. Thus, satellites

[25] Dall (2017)

[26] Lefeuvre, F & Tanzi, Tullio. (2014)

equipped with multispectral sensors (i.e. utilising different bands of the spectrum) can provide data that allow the quantitative classification of different types of land cover in a given scene.

During the year, trees can shed or grow leaves and fruit depending on variables such as temperature, sunlight, and precipitation. Soil characteristics can also further affect tree growth. Changes in the health, density, vigour and productivity of trees affect the optical properties of the canopy. The use of remote sensing - especially in the red and infrared spectrum - and other proximal sensors enables the mapping of changes (essentially related to vegetation reflectance) across an area and with time, thus enabling the monitoring of tree development and growth. Land cover classification can also be achieved using SAR satellites. Contrary to optical satellites – which essentially produce photographs, the SAR imagery is a measure of how much energy is scattered back to the sensor after being reflected on different types of materials.

In all cases, the data collected by EO satellites is transmitted via radio waves to properly equipped ground stations. There they are translated into a digital image that can be displayed on a computer screen. Each satellite image is composed of pixels and each of these pixels represents a square area on the image that is a measure of the sensor's ability to resolve (see) objects of different sizes. The higher the resolution the greater the ability of the sensor to discern smaller objects, but also the narrower the strip of land that can be surveyed by the satellite.

Measuring plant properties

Thanks to this stream of data, a wide range of monitoring and advisory services for forestry can be developed. The most common entails the measurement of the Normalised Difference Vegetation Index (NDVI). NDVI quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs). Healthy vegetation (chlorophyll) reflects more near-infrared (NIR) and green light compared to other wavelengths. But it absorbs more red and blue light. Calculations of NDVI for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1). Knowledge of the distribution of this index across a given field and in connection to the applied forestry practices (e.g. fertilisation or irrigation), allow forestry managers to make informed decisions on what is needed where and when. To ensure EO data's suitability in various applications, in-situ data can also be used to validate the remotely sensed data.

3.1.1 Advantages

The most important advantages of satellite-based forest monitoring applications include:

- The **capability to acquire data anywhere in the world** without any limitation by weather conditions (when combining optical and SAR) or the impact of the phenomenon itself. Satellites offer a **robust source of near-real-time**[27] **information** to aid forest management.

[27] "Near real-time" has a different meaning based on the application being studied. In the context of agriculture, near real-time is understood to be a few days. For a comprehensive overview on this we recommend a recent publication by Defourny et al. (2019) https://www.sciencedirect.com/science/article/pii/S0034425718305145

- The ability to generate **consistent, comparable and relatively objective** (i.e. not depending on individual interpretation/observation) information, collected **systematically on multiple scales, from local to regional to nation-wide;**
- The capability to **supply regular, detailed updates on forest and tree status** on a local, regional or national basis. By combining different satellites, this can be even done on a **daily basis** offering an invaluable resource to farmers.
- Satellite images offer spatially continuous data coverage of an entire area, with no further interpolation required, in contrast to ground-based discrete sampling. As such, they can serve as a basis for interpolation of information gathered in situ.
- Finally, whilst EO satellite data are a complementary data source to in-situ data (as well as airborne data, socio-economic data, and model outputs) in most countries, they **can be the only reliable source of information in countries lacking the ground infrastructure.**

3.1.2 Limitations

When compared to alternatives such as on-site or aerial surveys, satellite-based forestry mapping presents the following limitations:

- Resolution and active sensor limitations – spatial resolution may not be high enough to detect the required data at small scales or sensors may not be capable/suitable for certain applications.
- Non-daily revisit times for high resolution, non-commercial optical satellites – However, in the application of forest monitoring, daily revisit times are generally not necessary.
- Possibility of gaps in data availability due to cloud cover.

On-site surveys in particular offer information about soil chemistry and physical properties at different depths below ground which cannot as of yet be fully replicated with either satellite or aerial remote sensing. These soil characteristics tend to be less dynamic by nature than vegetation growth and in consequence, do not have to be reassessed as often.

Until a few years ago, another potential limitation was the cost of acquiring satellite data. That has progressively changed, first thanks to Landsat[28], and then with the advent of the Sentinel era – producing vast amounts of data under the Copernicus full, free and open data policy.

3.2 Copernicus and the Sentinels

The service studied is based on the use of both Sentinel-1 and Sentinel-2 data coming from the European Copernicus programme, so we shall start with a simple overview of the programme to place the services into context.

[28] https://www.usgs.gov/core-science-systems/nli/landsat

Copernicus is an EU flagship programme[29]. Copernicus started out as GMES (Global Monitoring for Environment and Security) with the goal of meeting European geo-information needs. At its heart is the most complete, operational satellite system in the world; owned by the EU and operated by ESA and Eumetsat and currently comprising six types of satellites, see figure below.

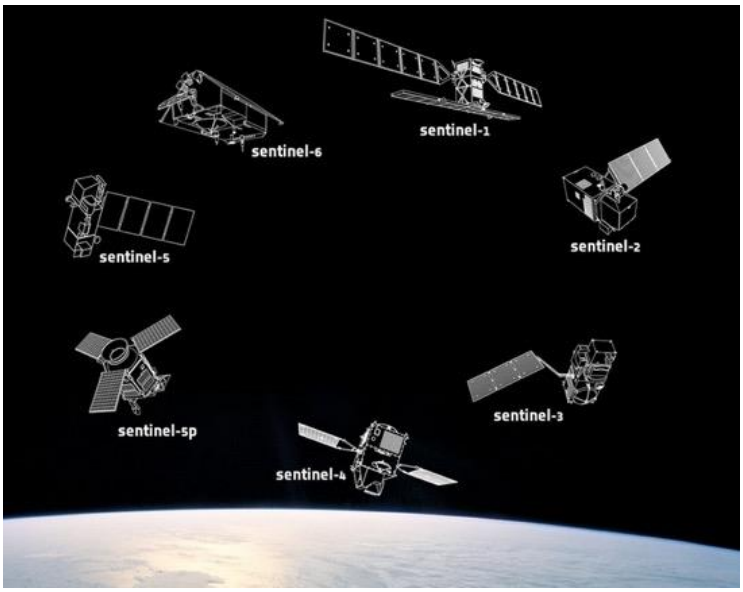


Figure 3-3: Current Sentinel satellites

This case is defined by both Sentinel-1[30] and Sentinel-2[31] (see the info boxes below).

[29] https://www.copernicus.eu/en

[30] https://sentinel.esa.int/web/sentinel/missions/sentinel-1

[31] https://sentinel.esa.int/web/sentinel/missions/sentinel-2

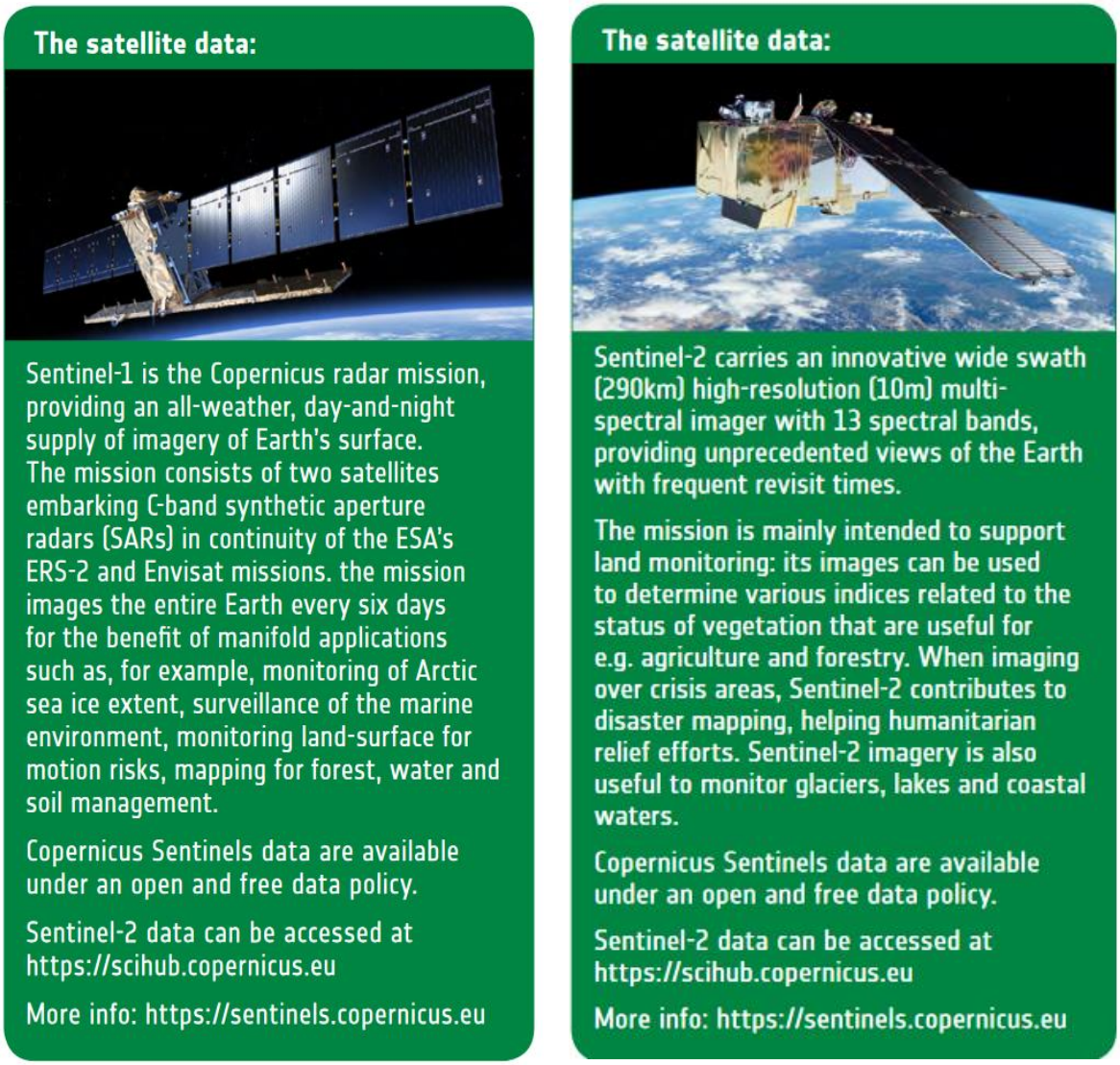


Figure 3-4: Sentinel-1 and Sentinel-2 satellites

Sentinel-1 carries a Synthetic Aperture Radar (SAR) operating in C-band. The two-satellites Sentinel-1A and 1B provide high-reliability data with a short revisit time, global coverage and rapid data dissemination to support operational applications. As already discussed, SAR is an effective and important technique in monitoring forests because its quality does not depend on weather conditions, cloud cover or day/night light coverage. Sentinel-1 SAR can be used to complement optical and NDVI data which is derived from Sentinel-2 (this will be further discussed in the following paragraph).

Sentinel-2 is a wide-swath, high-resolution, multi-spectral imaging mission. Sentinel-2 carries an optical instrument payload that samples 13 spectral bands: four bands at 10m, six bands at 20m and three bands at 60m spatial resolution. Normalized difference vegetation index (NDVI) is a simple graphical indicator that can be derived from Sentinel-2 data which helps to assess tree

vegetation health based on how the vegetation reflects light at certain frequencies. Sentinel-2 helps in monitoring soil properties as well as tree or vegetation conditions. It helps forest managers to monitor seasonal changes, assess land use and assist in implementing policies for sustainable development.

3.3 The Satelligence Service

The Satelligence deforestation monitoring service uses optical and radar data from Sentinel-1, Sentinel-2 and Landsat. Satelligence's service defines deforestation as land-use changes which counteract the sustainable production of commodities which their clients are trying to avoid. This means they do not see deforestation as simply the loss of tree cover. For example, the cutting down and replanting of an old plantation is not the type of deforestation that their clients are worried about. Rather, they detect the logging of trees in natural (intact) forests. Satelligence can differentiate between plantations and natural forests in the several ways:

- Natural forests can be distinguished from cleared and replanted areas using historical satellite data archives. These provide the ability to understand the minimum age of forests as well as planted or regrown areas.
- Forests can be distinguished from plantations by comparing seasonal effects of natural forests to those of known plantations using temporal features.
- They also distinguish forests from many plantation types on a pixel level using open data as well as their in-house commodity maps, created using optical and radar data.
- They compare the texture of natural forests to that of structured plantations, where the fluffy green canopy of natural forests is distinguished from more organised canopies of plantations.

The service creates what are known as "deforestation alerts". These alerts let clients know that deforestation is occurring on or close concessions which clients are sourcing from. Different levels of alert are given depending on how close to a concession deforestation has been detected. These alerts allow for concessions to be called into question and investigated. If they are indeed found to be contributing to deforestation, they will be placed on the "grievance list" for that client and will not be sourced from again until they can prove sustainable operations. The client can also maintain a "grievance overview" which shows who is currently not being sourced from. These alerts can be disseminated via a user-friendly web-application or clients can opt for an API that allows for a tailored solution which can be integrated with a client's own dashboard or GIS solution. Alternatively, PDF reports can simply be issued. Deforestation alerts are created as follows:

1. The optical and radar satellite data is pre-processed and compared to previous satellite imagery.
2. These changes are compared to Satelligence's in-house developed baseline to determine if it concerns deforestation and not harvesting of plantations or other agricultural activity.
3. Areas that were forest before and appear bare in the current imagery are tagged as deforestation patches.

4. Alerts are filtered based on area size and checked for intersections with other relevant datasets for prioritisation of alerts.
5. This automated rule-based risk prioritisation algorithm is then parameterised in consultation with clients.

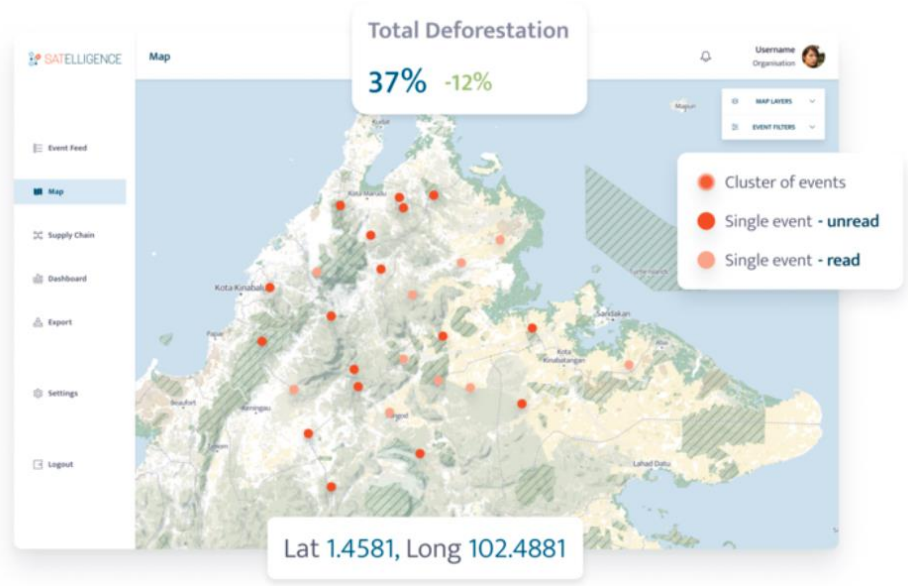


Figure 3-5: Satelligence's deforestation monitoring service web application

The Satelligence algorithm was built in close cooperation with Wageningen University and the change detection methods used have a verified accuracy based on peer reviewed and published science[32]. Given the fact that each area on the globe is different in terms of forest types and deforestation practices, the accuracy of the service is not the same for all areas. Satelligence's algorithms therefore must be "tuned" for each given region. Satelligence report that in doing so they can achieve at least 90% accuracy for a region. Given the fact that their primary focus for deforestation related to palm oil is in Southeast Asia, their service currently demonstrates 98% accuracy for prioritised alerts in Indonesia and Malaysia.

3.3.1 Future Evolution of the Service

After the initiation of their deforestation monitoring service, Satelligence have enhanced various algorithms and parts of their GIS solution to allow them to offer other types of services. This includes extension of the service to not only detect deforestation related to palm oil production, but also to the production of cocoa, soya and beef. They have also developed a supply chain monitoring service which helps clients to identify environmental risks across supply chains, meet legal requirements associated with sourcing and make better investment and sourcing decisions. In 2021 they also began an ESA funded project called "eOrigins" which aims to explore the idea of incorporating distributed ledger technologies (including the likes of blockchain) into remote

[32] https://edepot.wur.nl/450439

sensing-powered supply chain monitoring for major food industry players. Other services developed by Satelligence include services that can monitor carbon stocks and sequestration potential of forests and in 2020 won a World Bank Innovation Challenge[33] award for developing service that is capable of forecasting pest and disease alerts for Fall Armyworm (a type of moth) risk and identifying probable risk areas in Ghana.

[33] https://www.worldbank.org/en/events/2020/03/09/agriculture-risk-innovation-challenge

4 Understanding the Value Chain

4.1 Description of the Value-Chain

This case, as mentioned already, revolves around the palm oil supply chain and the ability to monitor its environmental impact. This ability, enabled by the satellite-based services provided by Satelligence, enables supply chain actors to promote sustainable palm oil production. It is thus precisely this ability that gives rise to the value chain we will be studying. In practice, the use of satellite data at the entry point of the value chain, results in enhanced information or improved operations that bring value for each link further down the chain. Ultimately, the implementation of more sustainable palm oil production (both from an economic and an environmental point of view), results in benefits experienced by our society at large at the far end of the value chain. But before we dive into the individual links and attempt to quantify the benefits (this is done in chapter 5) it is instructive to understand how the use of satellite data helps actors along the value chain to address the challenges that shape their own operational reality. Thus, in the following sections we provide details on the interests and responsibilities of the stakeholders in each tier.

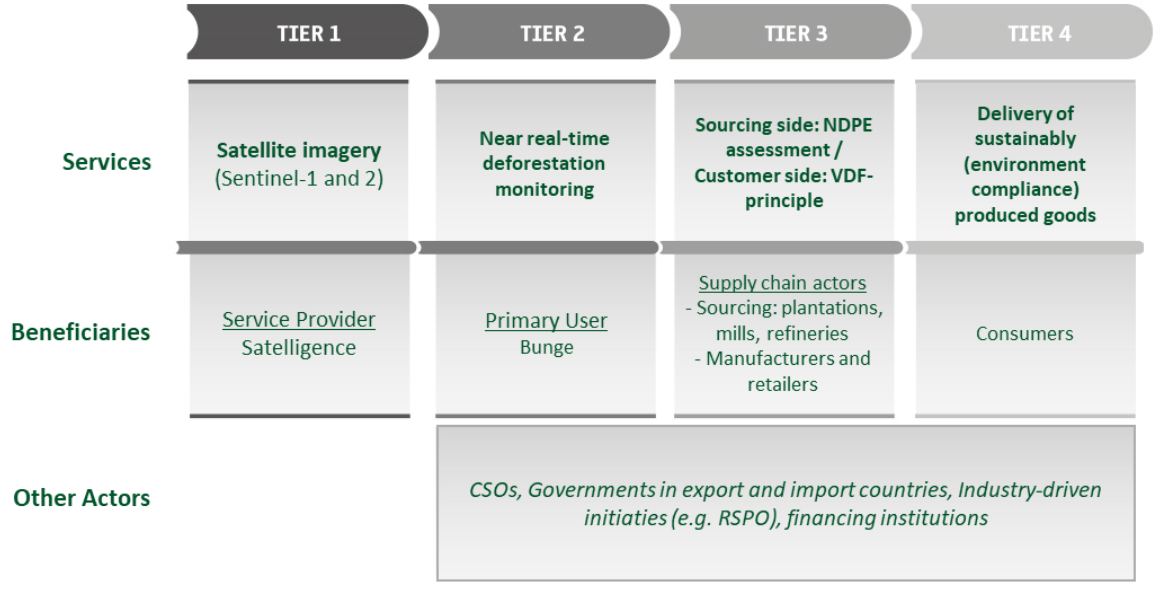


Figure 4-1: The value chain for Deforestation Monitoring of Palm Oil Production

4.2 The Actors

4.2.1 Tier 1: Service Provider – Satelligence

Satelligence represents a fine example of how the vision, sectorial and technical knowledge of its founders can translate into cutting-edge services powered by the use of satellite data and meeting real world challenges. Before founding Satelligence, Arjen Vrielink and Niels Wielaard, had both studied in relevant fields (tropical land use and forestry respectively both at the Wageningen University), worked in GIS, remote sensing or IT positions and done fieldwork in Southeast Asia.

Already during their studies, they had looked into topics that would much later become a core part of their work at Satelligence; for instance, Niels did his Thesis on "*Remote Sensing to support Sustainable Forest Management Certification in Indonesia*". The experiences allowed them to gain first-hand insight on how the Palm Oil industry operates, what challenges it faces and how satellite-based remote sensing can offer part of the solution. Thus, they founded Satelligence in 2016, with the aim to offer services that help organizations get insights into when and where deforestation is happening in their supply chain. Today, Satelligence numbers 26 employees and has offices in the Netherlands (Utrecht), US (Washington DC), Ghana (Accra), Bolivia (Cochabamba) and Indonesia (Jakarta).

Figure 4-2: Satelligence team on the ground

The timing of Satelligence's founding was very well tuned to their vision for services that support zero deforestation. Firstly, the free, full and open Copernicus Sentinel data was the powerful tool they needed to build affordable services that meet the needs of targeted clients. Secondly, the notion of corporate responsibility in relation to the environmental impacts was undergoing a significant cultural shift, with companies moving from seeing environmental sustainability as an annoying liability to treating it as a strategic asset. In that context, Satelligence has progressively built information services that support an impressive portfolio of high-profile, diverse and multipurpose clients (e.g. Bunge, Cargill, Wilmar, GAR, Musim Mas, Mondelez, Unilever, Pepsico, WorldBank, IFAD, Rabobank, ING Bank, Robeco, Actiam, Solidaridad, WWF, SOS, UTZ) take action against deforestation by deploying field teams, engaging with suppliers or even stop collaborating with unsustainable producers or traders. Thanks to its strong proposition, Satelligence has recently managed to become the first remote sensing company to have its deforestation monitoring services assured by a "big four" accounting firm (in this case Ernst & Young).

4.2.2 Tier 2: Primary User – Bunge

Bunge celebrated its 200th year anniversary in 2018. Starting as a trading company in Amsterdam, the company became a major agricultural commodities player with a global footprint and annual revenues of over $40 Billion. Bunge's operations include buying grains, oilseeds and softseeds from farmers, then storing, transporting and selling them to domestic and export customers. The company also provides financial, risk management and logistics services.

Figure 4-3: Bunge's operations – the refined and specialty oils are particularly in scope

When it comes to Palm Oil, Bunge is not a palm plantation company but acts as a palm oil processor and trader. More specifically, Bunge Loders Croklaan – a subsidiary of Bunge Limited – is a leading global producer and supplier of sustainable premium quality vegetable oils and fats for the food manufacturing industry. In 2014[34] just two years before Satelligence was founded, Bunge announced its updated palm oil sourcing policy. This, in line with goals set out by the Roundtable on Sustainable Palm Oil (see more on this below under "other beneficiaries"), set forth the principles of sustainable and transparent sourcing of palm oil. These include *inter alia* forest and biodiversity protection, reduction of GHG emissions and traceability. What's more Bunge has made a public commitment to reach deforestation-free value chains by 2025, which they claim to be the most ambitious deadline at that scale of operations in the industry.

In practice, meeting these commitments requires Bunge to have an accurate and up-to-date awareness of the practices of its suppliers and their conformity with no deforestation, no peat, no exploitation (NDPE). Thus, Bunge needs to know whether the suppliers with whom it cooperates or plans to do so source their palm oil from plantations engaged in deforestation. To that end, already since its founding year in 2016, Satelligence has worked with Bunge to implement a real-time deforestation alert system in Malaysia, Indonesia, and more recently in Honduras. The resulting

[34] https://www.bunge.com/sustainability/palm-oil-sourcing-policy

service[35] has allowed Bunge to perform informed due diligence of its suppliers and take action against those not complying. This may range from completely stopping cooperation with existing suppliers to overseeing appropriate conservation/restoration/compensation measures for potential new suppliers whose plantation development is incompatible with Bunge's policy. Beyond making it possible to find non-compliant suppliers, the service Satelligence offers to Bunge provides objective evidence for certification or verification of deforestation-free production. This evidence is essential when investigating grievances individually or together with NGOs and governmental authorities[36].

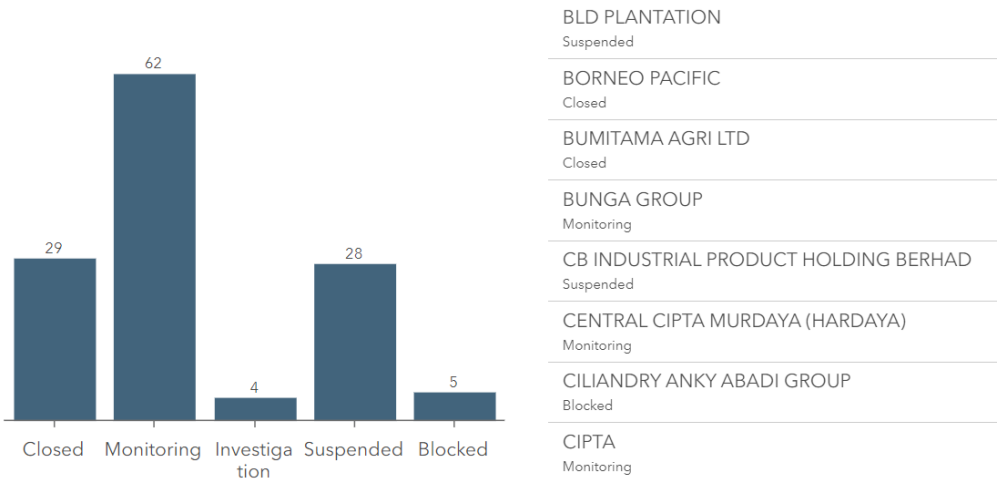


Figure 4-4: Bunge's grievance list

All this comes together in Bunge's sustainability report[37], which includes concrete updates on its non-deforestation commitment and makes direct reference to the services of Satelligence.

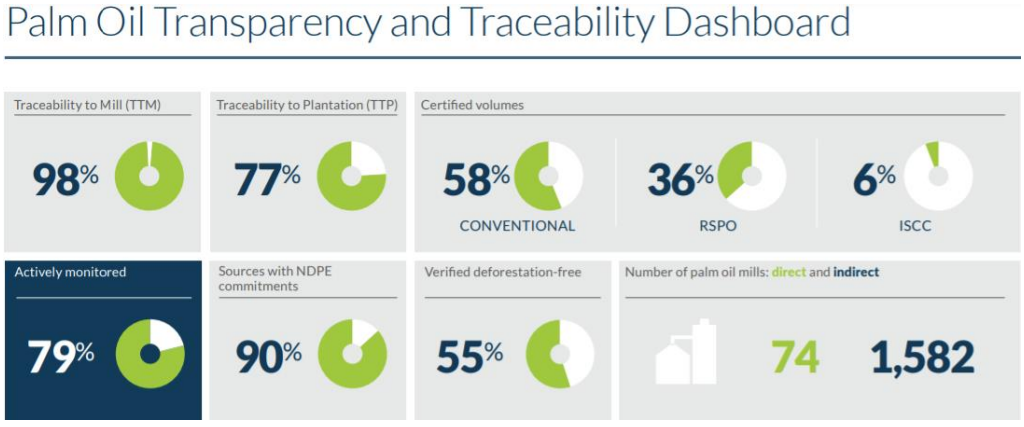


Figure 4-5: Extract from Bunge's sustainability report presenting KPIs on its NDPE status

[35] https://bungeloders.com/en/verification-using-satellite-monitoring-technology

[36] https://europe.bungeloders.com/en/material/palm-oil-dashboard-2020-full-year

[37] https://bungeloders.com/assets/2021-06/2021_Global_Sustainability_Report_Bunge.pdf

Meeting these commitments with the help of the services provided by Satelligence not only helps to secure a positive "Environmental, Social and Governance" (ESG) profile for Bunge but, as we will see in Chapter 5, supports its "investability". Furthermore, it helps Bunge promote a transparent and sustainable supply chain with direct implications for the other actors involved in it.

4.2.3 Tier 3: Food Supply chain actors (sourcing and retailers)

As presented in chapter 2, the palm oil supply chain involves a multitude of actors. To illuminate who these actors are and what operational realities they are faced with we can look into a nice representation of the supply chain[38].

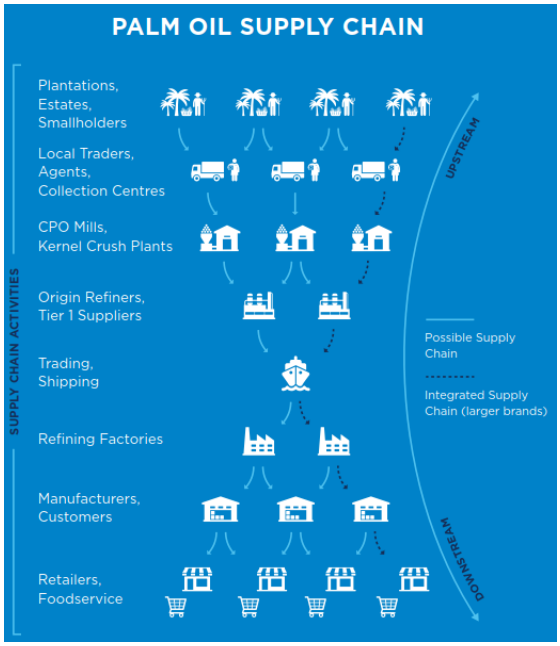


Figure 4-6: Palm Oil supply chain

This figure shows us that before palm oil reaches actors such as Bunge (i.e. refiners and traders), it is produced in raw form in various plantations, sourced by local traders and collection centres, and then processed in CPO Mills and Kernel Crush Plants. These actors form the sourcing side and, when it comes to their relationship with Bunge must comply to the sustainability commitments in place. This means observing non-deforestation production of palm oil, no new developments on peatland, no exploitation of the workforce or local communities.

Plantations

Palm oil is produced on one hand by millions of smallholder farmers and, on the other, by hundreds of industrial plantations. The former are defined as those managing less than 50ha of oil palm plantations[39], having this as their principal source of income, whilst their family is the main source of labour. Interestingly, smallholder farmers are responsible for 40% of the total global production of palm oil and therefore have a significant role in observing environmentally friendly and sustainable practices. This is why companies such as Bunge have launched capacity building programmes[40] to help them obtain certification and comply with their own sustainability practices. In the particular case of Bunge, this is done through project ILHAM which trains farmers on good agricultural practices and soil rehabilitation. This relationship with major companies such as Bunge

[38] Taken from https://www.idhsustainabletrade.com/news/latest-data-shows-86-of-palm-oil-imported-to-europe-sustainable/

[39] https://rspo.org/smallholders

[40] A nice list can be accessed here: https://www.climatefocus.com/sites/default/files/20200312%20Smallholder%20Cocoa%20%26%20Palm%20Report%20Edited_FINAL_0.pdf

is essential for smallholder farmers, who find their livelihoods directly tied with the production of palm oil. For them becoming part of this supply chain is a major incentive which, however, can have both positive (increased income, better chances for education) and negative (employment abuse, deforestation) effects.

Beyond individual or clustered-together smallholders, many industrial plantations exist, managed by companies who also own and operate mills or even perform additional activities further down the chain. For example, among the many entities who work with Bunge one finds companies such as the Bell Group, a company that processes every year approx. 2.5 million metric tons of fresh fruit bunches (FFB), which is equivalent to 135,000 hectares of oil palm plantations. Another example is Kim Loong Resources Berhad owning 15,000 hectares for an annual production of 280,493 MT of crude palm oil (in 2021). As with smallholder – but at a much larger scale – such plantation owners seek to grow a viable business while adhering to environmental protection practices.

Figure 4-7: Smallholders account for 40% of the global palm oil production (photo credit: Bunge)

Mills and Plants

Within 24 hours of harvest, the collected red fresh fruit bunches are delivered to mills which are typically located just a few kilometres away from the mills. There they are processed (see chapter 2) to produce the various palm oil products. This includes not only the crude palm oil extracted from the flesh of the fruit and the palm kernel oil coming from the fruit's kernel, but also virtually all other parts of the plant as can be seen in the image below.

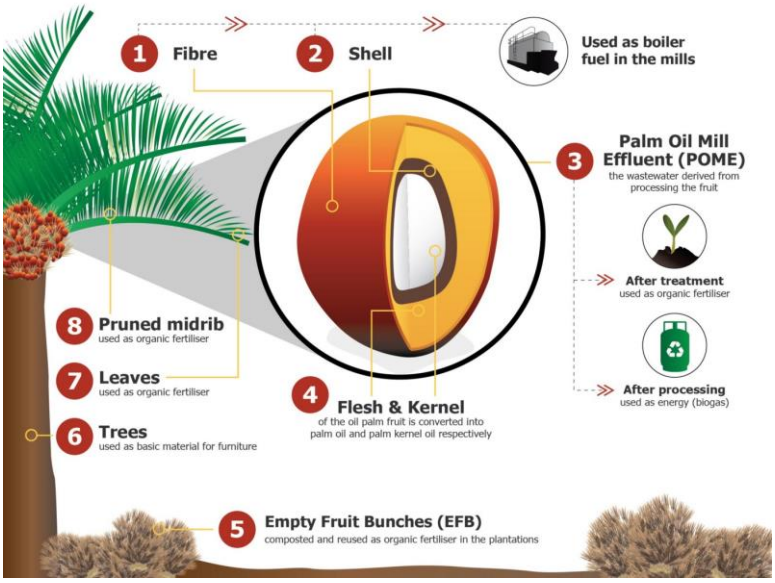


Figure 4-8: Palm oil as a zero-waste crop[41]

Thus, beyond the much coveted palm oil itself, palm plantations produce organic fertiliser and biogas.

Figure 4-9: Oil Mills in Southeast Asia[42]

Once processed, the outputs of the mills are sent to refineries as discussed below.

Refineries

Crude Palm Oil is transported to refineries where it undergoes multiple stages[43] of processing to become part of customer products. This includes degumming, bleaching, filtration, deodorisation, fractionation (to separate parts that become industrial frying fat from those becoming margarine, etc.) and packaging. Bunge has one refinery at origin in Peninsular Malaysia but also actively cooperates with the Earthworm Foundation who are working with multiple additional refiners. What is important when considering our particular case, is that Bunge is striving to not only trace all its sourced palm oil back to a mill but back to the plantation. As can be seen in figure 4.5, in 2020 this was achieved at 98% in the former case and at 77% in the latter. In the same graph, we see that

41 From: https://www.smart-tbk.com/en/tak-ada-limbah-yang-dihasilkan-dari-buah-kelapa-sawit/

42 Credit: Kretam Holdings Berhad http://www.kretam.com/index.php/our-business/2017-09-11-02-25-17

43 https://www.goldenagri.com.sg/palm-oil-refining-process/

Bunge collaborates[44] with 74 palm oil mills directly and with 1582 indirectly. For any case potentially breaching Bunge's sustainable palm oil sourcing policy, the alleged perpetrators are included into the grievances list and a verification procedure is launched (see below).

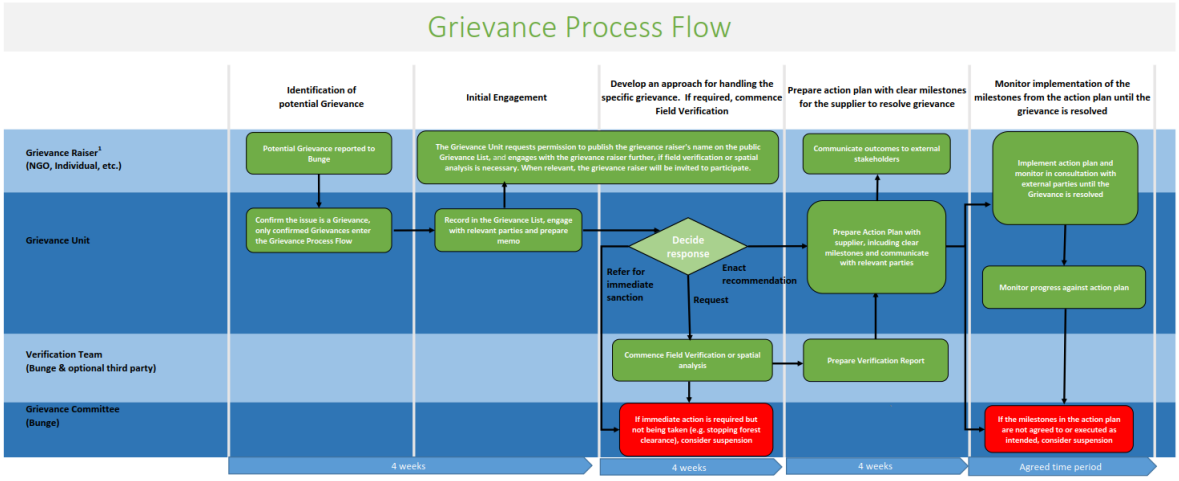


Figure 4-10: Bunge's grievance process flow

As can be seen above, the verification procedure involves on-site inspection (by either Bunge or third parties) or spatial analysis with the help of Sentinel-enabled products provided by Satelligence. For cases where deforestation can be associated with concessions from which Bunge or its partners source palm oil, better informed decisions can be made regarding future sourcing or collaboration. The effectiveness of the overall process is critical as it enables Bunge to monitor, report and meet its sustainability targets, with both direct and indirect benefits (i.e. investability, positive corporate profile). Looking at the year-to-year progress of Bunge's reporting one sees how from 17% of verified-deforestation free volumes in Q1 of 2019, it has exceeded 55% at the time of writing in 2021. At the same time the overall area being actively monitored is also expanding every year. Ultimately, the use of Sentinel-enabled services supports the journey of companies such as Bunge towards the desired levels of supply chain sustainability and, in turn, it allows manufacturers, retailers and, eventually citizens to enjoy good quality products with minimised environmental impact.

Manufacturers and Retailers

From major multinationals in the chemicals (e.g. BASF), cosmetics (e.g. L'Oreal), food (e.g. Froneri) and retail (e.g. Colruyt) sectors with a wide range of products relying on Palm Oil, to more specialised ones of various sizes, companies the world over rely on CPO, PKO, and other derivatives. The commitment of such companies to sustainably sourced Palm Oil varies greatly, as does their progress towards meeting this commitment. This can be clearly seen in the Palm Oil Buyers Scorecard maintained by WWF and monitoring major buyers of Palm Oil. One can immediately note that whilst many of these companies have joined relevant industry fora (e.g. RSPO), introduced time-bound commitments to source 100% RSPO CSPO and adopted dedicated strategies to

[44] https://europe.bungeloders.com/en/file_download/global-2020-full-year-mill-list

transform their palm oil supply chains accordingly, their actual progress against earlier goals (i.e. 100% by 2020) has been only partial. Thus, as reported in WWF's "Understanding the Journey" Report[45], few of the companies willing to fully disclose their progress have truly achieved their goals, even fewer have managed to document deforestation and conversion free palm oil.

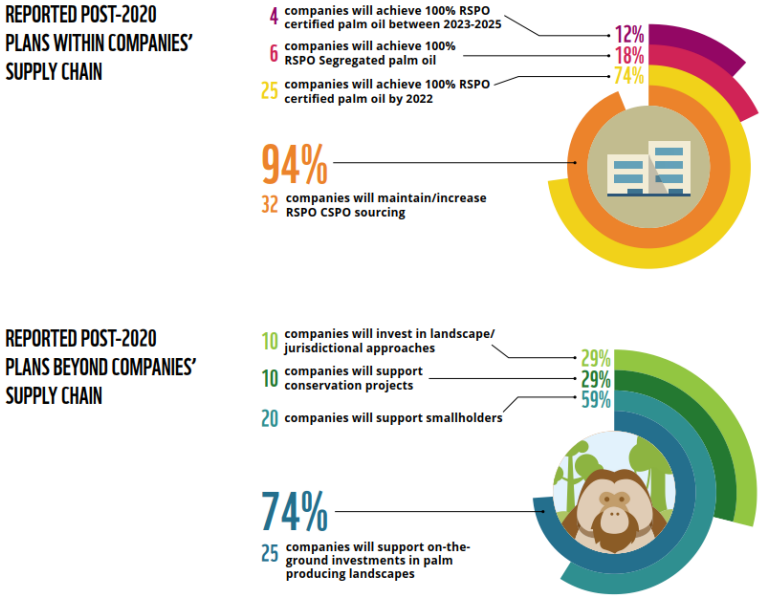


Figure 4-11: Status and actions reported by companies engaged in WWF's "Understanding the Journey" report

A closer inspection of the scorecards and some of the policies/strategies of these companies reveals important trends which are directly relevant for our analysis here. Thus, among these major companies most still struggle with traceability to the mills (only few claiming 100%) let alone to the plantations (only 1). Also, very few have imposed strict requirements for the suppliers to observe zero deforestation. These qualitative insights (from the WWF report previously mentioned) are further backed up by the analysis of the dataset made available by WWF on the 173 companies in the Buyers Scorecard. These insights are presented in the table below.

100% RSPO commitment by 2020	100% of total certified	Traceability to Mill	Traceability to Plantation	Supplier requirement on zero deforestation
70%	45%	28%	10%	7%

Figure 4-12: Status of sustainability commitment among the 173 companies monitored by WWF

When looking at what these companies consider as blocking factors for greater progress towards the achievement of deforestation-free palm oil supply chains they mention accessibility of and demand for RSPO CSPO, the intrinsic complexity of supply chain traceability (with some sourcing from thousands of mills), and limited upstream influence (i.e. the ability to push their suppliers to change their practices).

[45] https://palmoilscorecard.panda.org/files/download/9887cff953a3f8f

Clearly there is still great need for the uptake of Sentinel-enabled services that effectively unlock several of these problems as shown by the case of Bunge. In fact, several of these manufacturers and retailers have teamed up since 2019[46] to fund the development of a new, publicly available radar-based forest monitoring system known as Radar Alerts for Detecting Deforestation (RADD). This system, developed by the Wageningen University and Satelligence, has recently gone live[47] through the Global Forest Watch, providing insights on deforestation with the help of Sentinel-1. It is important to note that Bunge, Cargill, Golden Agri-Resources (GAR), Mondelēz International, Musim Mas, Nestlé, Pepsico, Sime Darby Plantation, Unilever and Wilmar have *financed the initiative for company use while also making it openly available as a shared public resource for good*.

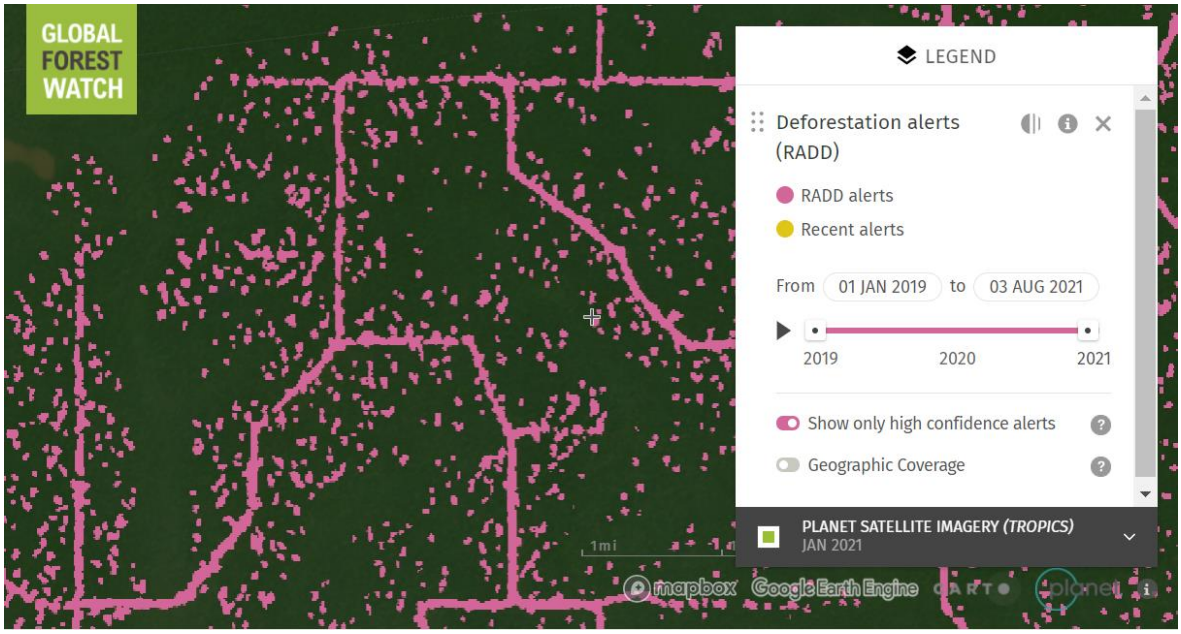


Figure 4-13: RADD deforestation alerts

Whilst the importance of such tools for supply chain traceability cannot be overstated, neither can the power of consumer awareness and regulation. We turn our attention to this now.

4.2.4 Tier 4: Consumers

Citizens have been a major driving force of the palm oil supply chain, not only as the ultimate user of the produced goods (which is applicable to virtually any supply chain) buts as agents of change, demanding that the products they consume are produced following sustainable environmental practices and ethical governance. This pressure has taken various shapes over the years: from totally boycotting palm oil products (resulting many to openly present that they are “palm oil free”), to boycotting only those products that do not bear some form of certification (from RSPO all the way to Verified Deforestation Free). Consumer awareness has, to a large extent, influenced

[46] https://www.wri.org/news/release-palm-oil-industry-jointly-develop-radar-monitoring-technology-detect-deforestation

[47] https://www.globalforestwatch.org/blog/data-and-research/radd-radar-alerts/

regulatory decisions at national and international (e.g. EU) levels around the use of palm oil leading even up to its total ban in certain circumstances. Yet, and whilst commenting on the ramifications of such regulatory acts is well beyond the scope of our study here, it is important to note that entities such as WWF have clearly highlighted why palm oil boycotts are not as helpful as they might seem. In that regard, the availability of publicly available data on deforestation (e.g. as through RADD mentioned above) enables increased transparency and a new level of consumer awareness.

In view of that, let us take a brief look on the role of "other beneficiaries" in our value chain.

4.2.5 Other Beneficiaries

CSOs

Given the prominent role of the palm oil industry in deforestation and biodiversity loss, it comes as no surprise that a large array of civil society organisations are active in this sector. This includes both major organisations such as WWF, Greenpeace and Global Forest Watch and specialised smaller-scale ones often operating specifically in countries with major palm oil production[48]. Regardless of their size, CSOs have played a significant role in implementing checks and balances on the palm oil supply chain actors, exposing the scale of deforestation, monitoring the progress achieved against it and contributing to the development of tools that can guide governments, industrial players, smallholder farmers or consumers. For instance, as already discussed, WWF operates the Palm Oil Buyers Scorecard; other organisations such as Earthworm and Greenpeace pioneered the development of the High Carbon Stock Approach[49] which has proven essential in defining what constitutes deforestation and pushing companies to uphold a higher standard. Many CSOs directly use satellite data – including from Sentinels 1 and 2 – to monitor palm oil plantations and provide objective evidence of deforestation.

Governments in export countries

Governments in the countries leading the export of palm oil globally (i.e. Indonesia, Malaysia and in recent years Colombia) are faced with a very complex situation. On one hand, the livelihood of their people is directly tied to a thriving palm oil industry. On the other hand, this very fact results in major environmental impact, several cases of workforce abuse and international outcry. In that regard, the transparency and objectivity of monitoring provided by satellite data may be both a blessing and a curse. In recent years, the governments of Malaysia and Indonesia have sought to curtail the transformation of land into palm plantations, organise capacity development activities

[48] See for instance the 60 NGOs who signed the open letter to RSPO in 2018 https://www.mightyearth.org/2018/07/31/over-60-ngos-call-for-stronger-reforms-to-the-roundtable-on-sustainable-palm-oil-rspo-standards/

[49] A very informative overview of the history of this approach is offered here: https://www.earthworm.org/cn/news-stories/a-short-history-of-the-high-carbon-stock-concept

and empower smallholder farmers. They have also fervently defended their palm oil related activities in international disputes such as the recent (practically ongoing) one with the EU[50].

Governments in Import Countries

The major importers of palm oil have varying degree of sensitivity to sustainability issues (incl. deforestation). In Europe a wide range of initiatives and developments are worth mentioning. At EU level, the recent Renewable Energy Directive (RED II) - 2018, foresaw that the EU *will phase out feedstock biofuels that involve high indirect land-use change (ILUC) by 2030, which only applies to crude palm oil*[51]. Earlier on, Denmark, France, Germany, Italy, the Netherlands, Norway and the UK have signed the Amsterdam declarations (on deforestation and on palm oil) - they were subsequently joined by Belgium and Spain. All these Member States, along with Portugal and Poland who have also been active, belong to the group of the biggest importers of palm oil; beyond this joint declaration all these Member States have taken various steps in developing and implementing *national-level approaches to diminish and eliminate the risk of deforestation embodied in imports*[52]. However, only a few Member States have taken legislative measures related to the actual consumption of palm oil products. This includes the Netherlands – who already since 2016 has stopped using biofuels based on palm oil for its domestic consumption and France who has ended tax benefits for palm oil-based diesel and introduced mandatory reporting requirements regarding deforestation risk.

Industry-driven initiatives

Several industry-driven initiatives have been launched over the years with the aim to introduce transparency in the palm oil supply chain, minimise its environmental impact and, ultimately, improve the sector's outward image. These initiatives can be classified in different types as per the "*EU legal framework to halt and reverse EU-driven global deforestation*"[53]:

- Collective aspirations: initiatives such as the Consumer Goods Forum (CGF), launched in 2010, or the European Palm Oil Alliance, gather major global actors (retailers, manufacturers) and put forward the aspiration of the sector to pursue zero deforestation commitments
- Company pledges: initiatives such as Forest 500 and Supply Change provide up-to-date rankings of major companies and financing institutions thus documenting their progress against their pledges
- Sectorial standards: the Roundtable for Sustainable Palm Oil (RSPO), arguably the most important collaboration among industry leaders, NGOs and investors, has established the standards for certification of sustainable palm oil and runs programmes for smallholder

[50] See for instance https://www.euractiv.com/section/agriculture-food/interview/malaysian-minister-palm-oil-is-a-deal-braker-for-eu-asean-trade-relations/

[51] https://www.tandfonline.com/doi/abs/10.1080/00074918.2020.1862411?journalCode=cbie20#:~:text=as%20palm%20oil.-,CONCLUSION,applies%20to%20crude%20palm%20oil.

[52] See https://www.europarl.europa.eu/RegData/etudes/STUD/2020/654174/EPRS_STU(2020)654174_EN.pdf

[53] ibid

farmers; similar organisations such as the European Sustainable Palm Oil (ESPO) are also aiming to ensure RSPO-certified palm oil in Europe.

Bunge, the primary user in our value chain is a member and often driving force in many of these initiatives.

It is important to also note that the RSPO has itself sought to make use of geospatial data for the sake of monitoring palm oil plantations. It has its own GIS unit and has been collaborating with major actors (e.g. World Resources Institute, Global Forest Watch). Recently, the RSPO has embarked on a collaboration with NASA/NOAA[54] to launch the Hotspot Hub, a facility using various satellite inputs to displays hotspots as indications of heat sources on the ground, ultimately linking them with fires associated with palm oil plantations.

Financing institutions

Financing institutions, be it banks, investors or insurers, play a central role in the palm oil industry. By providing financial support to supply chain actors they allow them to pursue their operations. Thus, if they support and invest in assets of palm oil supply chain actors whose operations are compatible with sustainability goals and practices, financing institutions are effectively setting a solid framework within which reduced deforestation and overall environmental impact can be observed. Of course, given the prominence palm oil has gained in the public debate, financing institutions have additional incentives to invest in companies who can retain a positive image, not have their products boycotted, etc.

In light of this, it comes as no surprise that entities such as WWF – in close collaboration with the RSPO – have provided already since 2012 guidance to investors[55], urging them to incorporate sustainable palm oil practices within their criteria for Environmental, Social, and Governance (ESG) credentials of the companies they invest in and, very importantly, not to divest from the sector[56]. It should also be noted that investors are directly involved in the RSPO.

Different types of risk enter in the picture (see graph below), all of which may directly or indirectly affect the business operations, creditworthiness and financial outlook of involved parties. Recognising the importance of such risks, investors have been adopting more rigorous practices to ensure that sustainability is incorporated in their financial tools and companies being invested in are providing adequate traceability and frequent reporting on their progress. This is perhaps best exemplified in a recent statement by 56 global investment organisations. To put things a bit further into perspective, back in 2012 when WWF produced its Palm Oil Investor Review, they analysed 68 companies with palm oil plantation interests representing $152 billion in total market capitalisation! This highlights how high the financial stakes are.

54 https://rspo.org/news-and-events/news/hotspot-hub--rspo-strengthens-fire-prevention-with-satellite-technology

55 https://www.rspo.org/file/Palm%20Oil%20Investor%20Review%20Web%20Version.pdf

56 https://d2ouvy59p0dg6k.cloudfront.net/downloads/wwf_statement_on_the_role_of_financial_institutions_in_palm_oil_sector_sustainability.pdf

RISKS	HOW RISKS CAUSED BY UNSUSTAINABLE PRODUCTION CAN ERODE SHAREHOLDER VALUE
Compliance risks	– Violation of regulations leading to fines and/or suspension of plantation manager's/owner's concession, operating licences or land lease.
Social risks	– Conflicts with local communities and labourers leading to industrial stoppages and operating losses; – Pressure from NGOs leading to loss of social licence to operate.
Market risks (product markets and financial markets)	– Loss of market as demand for sustainable palm oil grows; – Reduction in access to capital as lenders reluctant to finance operations and credit risks increase; – Fewer trading partners, reduced international opportunities; – Import/export embargo imposed against country can result in collapse in market access; – Divestment by risk capital investors – pressure on share prices.
Reputational risks	– Unsustainable practices damaging reputations; – Indirect reputational risks to trading partners; – Consumer backlash leading to boycotts and reduced sales; – Increased media pressure, both locally and internationally, can erode brand value.
Productivity risks	– Soil erosion, water contamination and failure to maintain site fertility will reduce future yields and returns; – Planting on peat lands is a high cost and low yielding practice that will impact margins; – Failure to maintain biodiversity will eliminate natural pest control animals and increase costs and pollution risks from use of pesticides; – Loss of natural habitat in and around plantations leads to localized climate differences, in particular a drier microclimate, which further reduce palm oil yields; – Suboptimal timing for planting of nursery palms (often planted at three years of age, which is too old) leads to lower productivity in the early years.

Figure 4-14: Different types of risks and their value/financial impact

In practice, by meeting their sustainability commitments, companies such as Bunge can secure favourable financing products. For instance, in 2019 Bunge announced it has successfully closed its first sustainability-linked revolving credit facility (the "Amended Facility")[57]. This was done with several major banks and accounted for $1.75 Billion.

Through this sustainability-linked mechanism, the interest rate was directly tied to the sustainability performance of Bunge against 5 performance targets spanning three areas:

- reducing greenhouse gas emissions by improving industrial efficiency;
- increasing traceability for main agricultural commodities; and
- supporting increasing levels of adoption of sustainable practices across the wider soybean and palm supply chain

[57] https://www.bunge.com/news/bunge-limited-closes-its-first-sustainability-linked-revolving-credit-facility

5 Assessing the Benefits

Now that we know which effects the Sentinel-enabled deforestation monitoring service is causing in the subsequent tiers of the value chain, we can establish the different types of benefits that are generated through its use. Which financial value can we attribute to the availability of the service? Which environmental or regulatory benefits can we identify? Are there any other social or scientific impacts that we can track? These are the questions we are addressing in this chapter. In this regard, it is useful to recall our value chain picture whilst adding the last two layers to it.

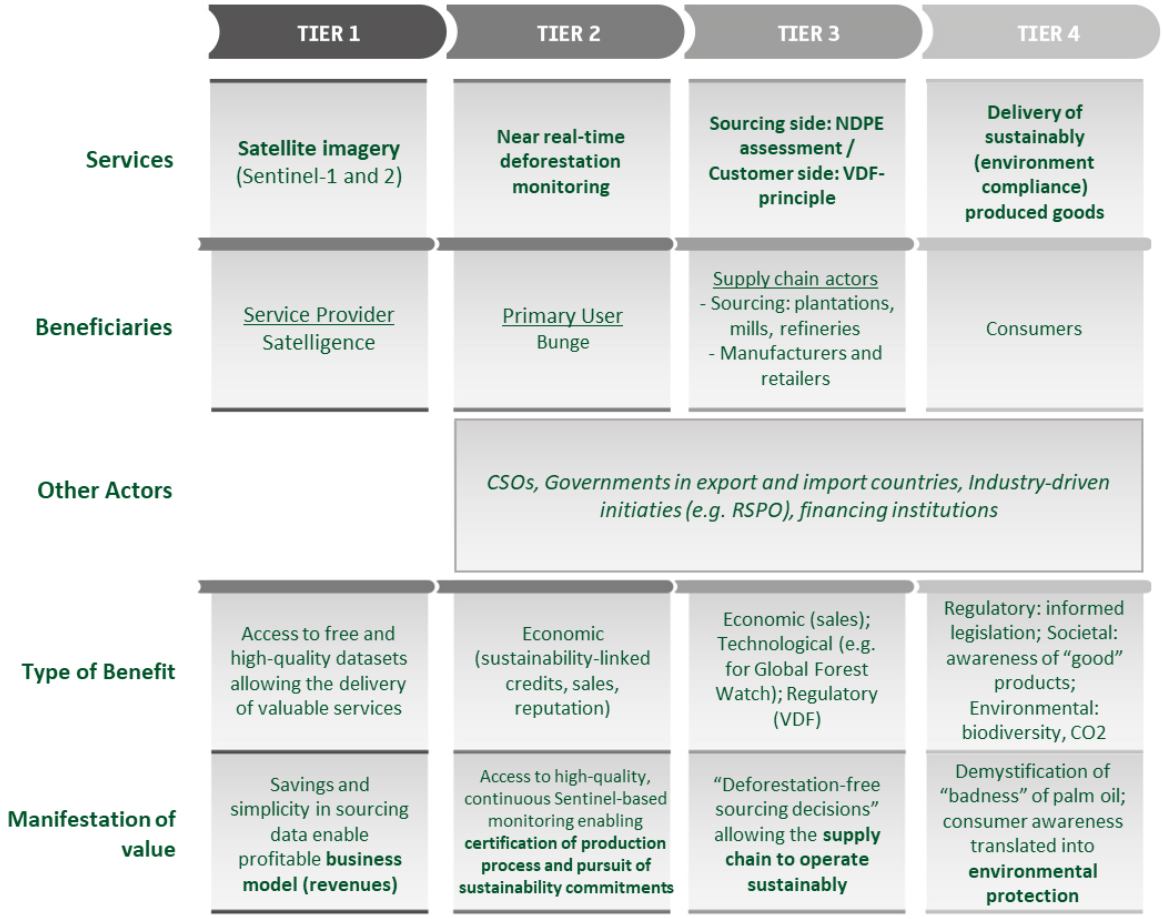


Figure 5-1: Benefits along the value chain

5.1 Overview

Before we dive into the discussion for each of the tiers it is instructive to make some high-level observations:

1. The use of the service by Bunge unlocks benefits for all actors in the value chain

By being able to monitor deforestation activities in its supply chain, Bunge not only experiences significant benefits themselves but also unlock significant benefits for the other actors in the value chain. Its suppliers can prove their conformity to sustainable practices and so can the customers of

Bunge, who can prove that they source deforestation free palm oil. Finally, governments and citizens can observe the adherence to regulation and the utilisation of sustainably produced goods respectively. Through well established relationships, other actors (e.g. NGOs) also benefit since they receive intelligence on potential deforestation allowing them to act and investigate or, where applicable, expose the culprits.

2. Economic, environmental and societal benefits go hand in hand

The ability to ascertain that palm oil is sustainable produced, with no deforestation and no new developments on peatland, triggers economic benefits for the actors involved but, at the same time, serves the greater environmental and societal purpose of protecting the environment. In practice, thanks to the Sentinel-enabled service by Satelligence, supply chain actors can progressively converge towards truly deforestation-free palm oil production. This means less contribution to climate change, better preservation of important habitats and good support to local livelihoods. In parallel, as companies such as Bunge innovate adopting satellite-based services to support their activities, this paradigm spreads within the community, maximising the overall impact of these services and even triggering further scientific and technological developments.

These high-level observations will be echoed in the detailed discussion of the economic value and other types of benefits arising from the use of Sentinel data in each Tier. These analyses have been generated thanks to the insights collected directly by the value chain actors and subsequent extensive research.

5.2 Benefits along the Value-Chain

5.2.1 Tier 1: Service Provider – Satelligence

Satelligence benefit hugely from the use of Sentinel data in many ways. Firstly, the fact that Satelligence's primary input data source is completely free means they consistently save large amounts of operational costs. Should Satelligence be required to pay for such huge amounts of rich data continually, their business model would most likely have to change dramatically and ultimately, profits would be reduced. Moreover, the Sentinel-1 and Sentinel-2 data being processed is central to the utility of the software that has been developed. Building and then expanding Satelligence's business may not have been possible without the use of Sentinel data as its free and open nature helps to unshackle the burden of large financial liabilities, which can often obstruct young start-ups from getting off the ground or can even disincentivise the initiation of a service or innovation entirely.

There are two ways in which we can quantify the economic value added at the service provider level as a direct result of using Sentinel data;

1) Measuring the magnitude of Satelligence's revenues which can be directly tied to the utilisation of Sentinel data;

2) Quantifying the economic added value associated with the number of workers employed by Satelligence and whose employment can be directly tied to the utilisation of Sentinel data.

To use the first metric, an in-depth analysis of Satelligence's accounting and financial figures would be required, however, due to privacy concerns this data could not be shared. We will therefore use the latter metric. As previously stated, Satelligence has expanded its enterprise to now employ 26 people. Satelligence's operations are so intrinsically linked to the use of Sentinel data that they consider their success and the annual employment of all their workers to be direct and entirely attributable to its use. **We will therefore use the average annual labour costs associated with 26 full-time employees in The Netherlands as the Tier 1 estimate for economic added value which can be directly attributed to the adoption of Sentinel data.** The reason we use labour costs and not annual gross or net salary figures is due to the fact that labour costs account for both wage and non-wage costs such as employers' social contributions. This gives a better approximation of the overall economic added value associated with the employment of a worker. The diagram below summarises the relation between net earnings, gross earnings/wages and labour costs.

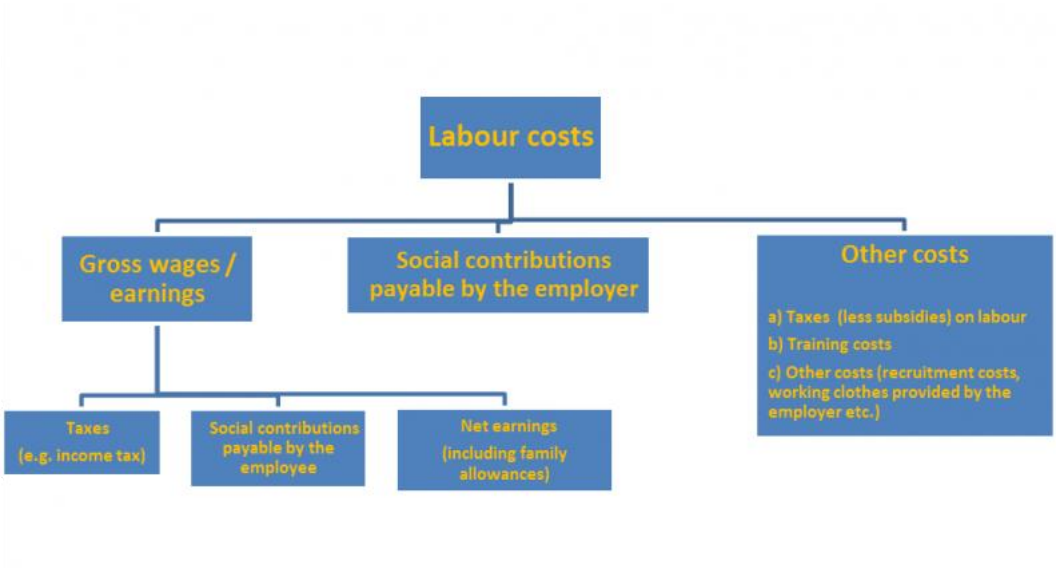


Figure 5-2: Labour cost components

In The Netherlands, the average hourly labour cost is €36.42/hour[58] with the number of average annual working hours being 1580.8 hours[59]. This implies that the average economic value of a full-time employee in The Netherlands is €57,573/year. **As a result, the employment of 26 employees yields a Tier 1 economic value estimate of €1.5 million/year.**

Given the specifics of this case and the fact that we have estimates of future operations associated with the use of Satelligence's service, we will provide a present value (lower estimate) and a future

[58] https://ec.europa.eu/eurostat/statistics-explained/index.php/Wages_and_labour_costs#Gross_wages.2Fearnings

[59] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Hours_of_work_-_annual_statistics#:~:text=When%20only%20employees%20are%20considered,employees%2033.7%20hours%20per%20week.

value (upper estimate) of economic benefit associated to the use of Sentinel data. Assuming a steady growth and expansion of the company over the next 5 years, (adding 3 employees next year, a further 5 the following year and 10 each year afterwards), by 2026 we estimate the economic value of Satelligence to be worth roughly €6.3 million/year. This figure will be counted as the future value of the tier 1 benefit in this case.

Beyond the economic aspects, it is important to note that Satelligence contribute greatly to the EU's innovation and entrepreneurial landscape thanks to their innovative use of Sentinel data to develop extremely valuable and cutting-edge software and services. Satelligence's unique use of Sentinel data in monitoring deforestation associated with palm oil cultivation has put them at the forefront of linking the use satellite data to sustainability in our food supply chains. In fact, when Ernst & Young certified their 2020 deforestation KPIs, Satelligence became the first ever remote sensing company to have a deforestation monitoring service certified by one of the big four accounting firms.[60] By adopting Sentinel data, they have been able to develop extremely valuable algorithms, techniques and services which serve their customers efficiently and effectively. The rapid growth of Satelligence and their portfolio of huge, influential customers is a testament to the efficacy and value of their innovative approach to applied remote sensing solutions.

The development of Satelligence's services also shows their commitment to environmental protection and societal change. Through their efforts, they have created services which help to ensure that our food supply chains remain sustainable. Their service is providing a real impact to the protection of forests, peatland and natural habitats, which, as discussed, also ultimately helps to contribute to the reduction of greenhouse gas emissions. Thanks to their service, food supply chain actors involved in the palm oil industry are being given less and less leeway in terms of their environmental performance and commitments. **Ultimately, Satelligence's services are helping to make our food supply chains more transparent and turning the tide of people's attitudes and expectations when it comes to the behaviour of large companies sourcing inputs in developing countries.**

5.2.2 Tier 2: Primary User – Bunge

As the primary user of Satelligence's service in this case, Bunge experience several types of benefits. First of all, Bunge can categorically ensure and prove that the palm oil they are sourcing is deforestation free. From Bunge's point of view, this helps to uphold their commitments and image as a reputable company, concerned with economic and environmental sustainability. Prior to the use of Satelligence's service and without the ability to remotely verify that palm oil sourced was indeed deforestation free, proving sustainability to customers, stakeholders and the general public was also a much more difficult, time consuming and less transparent task. Now, thanks to their utilisation of Satelligence's service, Bunge can monitor the sustainability of their operations and demonstrate this in an objective manner. There can be no doubt that through the demonstrable maintenance of sustainability and the upholding of their corporate reputation, Bunge experience

[60] https://satelligence.com/solutions

economic benefits. A company's reputation is an important intangible asset, which if damaged often leads to downturns in revenue or drops in share price. However, putting a price on one's reputation is a very difficult task. Numerous studies[61,62] have aimed at quantifying and understanding the economic benefits associated with corporate reputation. However, each study uses varying quantification techniques and ultimately, the benefits are extremely dependent on a multitude of individual factors and specifics relating to each company, with this type of analysis being outside the scope of this report. However, a more general approach can be considered; According to Reputation Dividend[63], a company who model the financial value of corporate reputation, 30% of a company's market capitalisation (the total market value of a company's outstanding shares of stock) can be underpinned by the company's reputation. **At the time of writing, Bunge's market capitalisation is valued at €11.33 billion ($13.061 billion)[64], meaning its reputation could be worth as much as €3.4 billion.** Although Satelligence's service undoubtedly contributes to this figure, we cannot affix to it an exact percentage which is directly attributable to the use of Sentinels. Therefore, this figure will stand as a very real indication of the value brought by Sentinels to Bunge but will ultimately remain an unaccounted economic benefit within this report. (**Note –** this figure was also not confirmed by Bunge and is solely the conclusion of the authors of this report).

We can however consider a **concrete and quantifiable economic benefit to Bunge from the use of this service.** This is **the favourable interest rate applied to the sustainability-linked revolving credit facility** (loan), worth $1.75 billion USD (€1.508 billion) which it received 2019. According to the terms[65], Bunge will pay between 0.3% and 1.3% interest on this loan depending on its sustainability performance. There are 5 "Sustainability Performance Targets" listed within the terms of the loan, with Targets 4 and 5 explicitly linked to palm oil. The finer detail of exactly what these targets are is not publicly available but the fact that they must be verified and "*assured by 3rd party*" is documented**. In other words, if Bunge can prove its performance in terms of sustainability commitments using Satelligence's service, it can derive a benefit of €5.03 million/year** (the revolving credit facility matures in after 3 years)**.** This is a truly tangible economic benefit which exemplifies just how valuable services such as Satelligence's can be to the likes of huge corporations like Bunge.

***Please note:* All economic analysis performed in this report was undertaken by the authors alone. It is based on publicly available data and was not confirmed by Bunge.**

The environmental benefits in this tier are clear; through Bunge only sourcing palm oil from reputable and deforestation free plantations and mills the sustainability of the food supply chain is being improved and Bunge are meeting their sustainability commitments. Large companies such as Bunge hold huge influence in our food supply chains, and it takes these companies making decisions

[61] https://www.scielo.br/j/rae/a/6jdZQCWTYG4mKRhYqsYshzQ/?format=pdf&lang=en

[62] https://onlinelibrary.wiley.com/doi/pdf/10.1002/smj.274

[63] https://www.reputationdividend.com/

[64] https://finance.yahoo.com/quote/BG/

[65] https://otp.investis.com/clients/us/bunge/SEC/sec-show.aspx?FilingId=13797039&Cik=0001144519&Type=PDF&hasPdf=1

and commitments to sustainability to act as catalysts in the fight for environmental change. By taking its corporate social responsibility seriously, Bunge are incentivising actors both upstream and downstream to ensure their operations do not harm the environment.

In fact, through their collaboration with Satelligence, **Bunge also contribute to the innovation landscape.** Indeed, **Bunge has been a first-mover and champion in the utilisation of Sentinel-enabled services for monitoring its supply chains, an innovative approach that has been since followed by more major companies, including the likes of Mondelez International and Wilmar International.**

A regulatory benefit is also evident in this tier. By adopting the services Satelligence provide, Bunge can easily and efficiently demonstrate and report how their operations are remaining compliant with given regulations or legislation. This relatively new technology will undoubtedly help influence the way authorities monitor and verify the sustainability of operations and adherence to regulation (similar to how the sustainability-linked revolving credit facility is monitored).

5.2.3 Tier 3: Supply chain actors (sourcing)

Through the actions of Satelligence and Bunge in Tiers 1 and 2, food value chain actors are heavily incentivised to adhere to cultivating, refining, and trading verified deforestation free (VDF) palm oil, otherwise they will not be sourced from or dealt with. Bunge's commitment to sustainability ensures actors upstream and downstream of them do the same. On the upstream side, plantations are rapidly becoming more and more aware of the fact that should they engage in environmentally damaging practices, this will not go unnoticed, and they will not be sourced from. The same goes for mills and refineries. On the downstream side, by ensuring their products are deforestation free, Bunge are trading in, and supplying sustainable products to food processors, manufacturers, and retailers.

Similar to the benefit experienced by Bunge, reputation maintenance undoubtedly brings benefits to the actors in this tier (plantations, mills, refineries, manufacturers and retailers). For the upstream side, being able to show your operations are sustainable allows you to remain on the "buy list" of reputable entities. Being removed from such a list or being shut down can have huge costs for a plantation or mill. For example, a study by the WWF[66] considered the following scenario:

- A typical 10,000-hectare plantation requires a mill that can process up to 60 metric tonnes of fresh fruit bunches per hour.
- At peak season, the mill may be running approximately 22 hours per day, 6 days per week.
- **If the fresh fruit bunches sell for $200 per metric tonne, it requires less than 4 days of disruption to reach $1,000,000 USD in costs to the company.**

66 http://assets.wwf.org.uk/downloads/profitability_and_sustainability_in_palm_oil_production_update.pdf?_ga=1.138981236.676885195.1409923783

This "disruption" can be triggered if plantations or mills are placed on a grievance list due to suspicions of deforestation (i.e. being in breach of sustainability requirements). The result is that their operation can be suspended (or at minima disrupted), potentially leading to "stranded assets" which in turn translate into huge financial losses.

The grievance process involves several steps, meaning it can easily take up to 6 months for an entity to be placed on the list, and often many months to be removed. Given the complexity of the process, the constant changes of the grievance list and the large number of entities being sourced from, we cannot categorically say exactly what the economic benefit is to the aggregate of upstream Tier 3 actors in this scenario. However, the fact that in only 4 days a typical mill can lose up to $1 million dollars shows the scale of economic benefit there is to individual entities who can prove the sustainability of their operations.

There is a second economic benefit for plantations, mills or refineries in this tier which relates to **premium pricing for certified sustainable palm oil**. Certified oil typically sells at a premium of about $30 USD a tonne on average more than the non-certified kind[67], although this can vary significantly depending on purchase volumes and negotiations between buyers and sellers. However, it costs producers at least $8 USD to $12 USD a tonne for certification (this includes the likes of internal and external audits). Nevertheless, a benefit of roughly €15.6 ($18 USD) per tonne can be experienced by producing certified sustainable palm oil. According to Bunge's Annual Communication of Progress to the RSPO in 2020[68] they sourced 677,329 tonnes of RSPO-certified palm oil. **This implies plantations, mills and refineries from which Bunge sourced the sustainable palm oil experienced economic benefits amounting to €10.6 million in 2020 thanks to their ability to prove sustainability.** Within the same document, estimations are provided regarding how much RSPO-certified palm oil will be sourced in the future. **Assuming market demand remains constant, Bunge are expected to source just over 800,000 tonnes of RSPO-certified palm oil in 2021 and 1.43 million tonnes by 2026. This provides current and future estimates of economic benefits to plantations, mills and refineries of €12.5 million and €22.3 million respectively.**

Actors downstream of Bunge such as food manufacturers and retailers also benefit from the ability to objectively verify deforestation free palm oil production, enabled by Satelligence's service. In practice, they can also show their commitment to sustainability through the use of Bunge products, thus upholding corporate reputation. Given the enormous number of these entities and the intricacies of the value of corporate reputation (discussed under Tier 2) calculating an economic benefit associated with the maintenance of reputation across all players is extremely complex and somewhat outside of the scope of this report.

When it comes to environmental and societal benefits, these are similar to those discussed in Tier 2. By upstream actors providing Bunge with sustainable palm oil and downstream actors buying sustainable products from Bunge, the sustainability of the food supply chain is being improved,

[67] https://www.afr.com/markets/commodities/the-world-has-loads-of-sustainable-palm-oil--but-no-one-wants-it-20190114-h1a1j8

[68] https://document.rspo.org/2020/Bunge_Limited_ACOP2020.pdf

rural communities are not being exploited and Tier 3 actors are meeting their corporate social responsibility commitments.

5.2.4 Tier 4: Consumers

In the final tier of this value chain, the manifested benefits primarily relate to environmental and societal dimensions. The customers and consumers of final products which have been made with sustainably sourced palm oil benefit by knowing what they are purchasing is less harmful to the environment and the communities from which it has been sourced. As discussed in Chapter 4, consumer awareness of food sustainability is one of the primary drivers for change in our food production and supply chains. By insisting more and more on sustainable products, consumers are shaping the way in which our food is sourced and produced. Through the actions of Satelligence, Bunge and the tier 3 actors, consumers can see for themselves the sustainability of the supply chain and the food it produces. Here it is important to highlight that **whilst the final consumer has no awareness at all that Sentinel data was used to ascertain deforestation free production, it is exactly this data that enables this to happen.**

5.2.5 Other Beneficiaries

CSOs

Thanks to the actions of actors in the value chain, CSOs such WWF, Greenpeace and Global Forest Watch have much greater visibility over how corporations are behaving when it comes to their sustainability commitments. The transparency provided by the Sentinel-powered service allows CSOs to monitor the progress of environmental and ecological targets and ultimately aids in them reaching their goals. This benefit is also often directly enabled by Satelligence or Bunge sharing deforestation intelligence with CSOs, allowing them to mobilise their resources more efficiently and to timely investigate illegal activities. In this regard, important benefits related to innovation on one hand and science and technology on the other are also realised, through partnerships between CSOs, industrial actors and scientific institutes (and of course Satelligence itself) to establish satellite-based monitoring systems. As discussed in chapter 4, this includes – but is not limited to – the radar-based forest monitoring system known as Radar Alerts for Detecting Deforestation (RADD)[69] and the Hotspot Hub[70].

Governments in export countries

As discussed in chapter 4, governments in export countries, for instance Malaysia and Indonesia, have sought to curtail the transformation of land into palm plantations in recent years. To that end, the ability to objectively show progress when it comes to the deforestation and sustainability goals is essential. This ability is unlocked thanks to the objective evidence provided by satellite-based deforestation monitoring. This can ensure that the international dialogue and associated

[69] See for instance here https://www.wur.nl/en/newsarticle/WWF-uses-the-RADD-alerts.htm

[70] https://rspo.org/hotspot-hub

agreements, regulatory actions and trade relationships (all of which have become contentious in recent years) associated with palm oil production and consumption, is well-informed. As a result, governments in export countries, are pushed towards and can prove progress with regards to ensuring ecosystems and rural communities are protected while greenhouse gas absorption capacity is protected in their territories.

Governments in import countries

On the other side of the equation, governments in importing countries benefit by being able to prove the sustainability of the palm oil which they are buying. Again, this helps importing countries comply with commitments made with regards to ethically sourced products. In the case of the EU, this can directly inform relevant regulation (see more in chapter 4), enabling EU bodies and Member States to engage in an informed public debate and make sound legislative proposals.

Financing institutions

As exemplified in the favourable interest rates given to Bunge on a sustainability linked loan, financing institutions seek to incentivise corporations to act more ethically. This is driven by significant economic considerations: **asset managers and investors whose portfolio includes companies with low sustainability performance see the value of their portfolio decrease**. Such considerations have turned "green investment" into a major trend of our times. Here too, the ability to objectively prove the fulfilment of sustainability commitments is an essential tool in the efforts of financing institutions – it is exactly this ability that the Sentinel-enabled service of Satelligence fosters.

5.3 Summary of Benefits

In this section, we draw together the different benefits to the stakeholders identified along the value chain, grouping them by six dimensions of value-chain analysis. A summary of the degree of the benefits as applicable to this case, taking into account previously studied cases, is shown below. The assessment is subjective; the basis for it is given in Annex A2.

Economic	Environmental	Societal	Regulatory	Innovation & Entrepreneurship	Scientific & Technological
★★★★	★★★★★	★★★★	★★★	★★★	★★

Table 5-1: Benefits Assessment by Category

5.3.1 Economic

The economic benefits are shown in the table below.

Tier	Benefits identified	Annual economic value stemming from the use of Sentinel-enabled services (in €)	
		Present	Forecast
Tier 1 (Satelligence)	Revenue linked to the use of Sentinel data	**€1.5 million**	**€6.3 million**
Tier 2 (Bunge)	Access to favorable interest rates on sustainability-linked loans	**€5 million**	
Tier 3 (Food supply chain actors)	Premium pricing for certified sustainable palm oil products	**€12.5 million**	**€22.3 million**
Tier 3 (Customers / Consumers)	**N/A**	**N/A**	**N/A**
TOTALS		**€19 million**	**€33.6 million**

Table 5-2: Summary of economic benefits

As discussed in previous sections, there are undoubtedly many economic benefits manifested in each tier of the value chain that have not been quantified within this report due to the many unknowns and complexity involved in performing this analysis. For example, in tier 2 our analysis suggested that Bunge's corporate reputation could be as valuable as €3.4 billion. Bunge's use of Satelligence's service certainly helps in maintaining this reputation, but to assign a percentage of this figure to the use of a Sentinel-powered service would require several assumptions and ultimately would be quite an uncertain figure. Therefore, it should be noted that the figures in the table are what could be objectively quantified within this report and are considered quite conservative in terms of the actual total economic value Sentinels are bringing in this case.

- Revenues linked to the use of Sentinel data (tier 1)
- Access to favorable interest rates on sustainability-linked loans (tier 2)
- Premium pricing for certified sustainable palm oil products (tier 3)

5.3.2 Environmental

By fostering sustainable production of palm oil, the Sentinel-enabled service offered by Satelligence to Bunge, enables a series of very significant environmental benefits.

Supporting the reduction of deforestation

This is at the heart of the case. Satelligence enables the continuous, objective monitoring of deforestation in and near palm oil plantations. Deforestation alerts are reported to Bunge who can then investigate the cases brough to their attention. With Bunge acting as a first mover, many more companies in this sector have adopted similar approaches, thus collectively converging towards a deforestation-free palm oil production. It must be underlined that the service of Satelligence does

not stop deforestation. Instead, it provides actors who have the power to do so with the necessary intelligence.

Protecting natural habitats

By reducing deforestation, the Satelligence service enables the effective protection of important natural habitats. The best known and possibly most critical case is that of orangutans, with Indonesia and Malaysia being their only remaining home today. Their habitats have been under constant threat from expanding deforestation, so the ability to monitor and eventually control it becomes a necessity. Other species have also lost their natural habitats, with their numbers significantly diminishing[71]. Entities such as WWF, have been coordinating actions in this regard, including the promotion of RSPO certification of palm oil production, something that can be objectively ascertained only through the use of satellite-based monitoring.

Minimising peatland conversion

The service offered by Satelligence to Bunge pays extra attention to areas of special interest. Beyond protected forests and concessions belonging to suppliers of Bunge, this includes peatland, whereby Bunge wants to ensure that no new development of palm oil plantations takes place. This is because the drainage of peatland required for palm oil cultivation results in peat oxidation, reducing the potential for carbon sequestration and increasing the risk of fires and floods. Ultimately, the minimisation of peatland conversion will help to reduce its contribution to climate change, with over 5% of global CO2 emissions currently associated with peatland degradation.

Reducing the contribution of palm oil production to climate change

In summary, less deforestation and less peatland degradation means less contribution of palm oil cultivation to climate change. The service offered by Satelligence to Bunge and similar efforts involving key initiatives such as the Global Forest Watch helps to make it clear among all involved parties, that the only way forward is truly achieving zero deforestation. Here it must be noted that despite significant progress, the achievement of this goal is still not as close as supply chain actors, governments, NGOs and citizens alike would have wanted[72]. Less pledge, more action is needed, and satellite-based services are an excellent tool pointing to this direction.

- Production and utilisation of deforestation-free palm oil (tiers 1, 2, 3 and 4)
- Maintenance of natural habitats and ecosystems (tiers 1, 2, 3 and 4)
- Maintenance of peatland and sequestration of CO_2 (tiers 1, 2, 3 and 4)

5.3.3 Regulatory

The transparency and objectivity of Sentinel imagery in this case allows for extremely efficient verification and certification of sustainable operations. As exemplified in the monitoring of Bunge's sustainability-linked revolving credit facility, remote sensing is continually showing its true efficacy

[71] https://www.worldwildlife.org/stories/endangered-species-threatened-by-unsustainable-palm-oil-production

[72] https://www.bloomberg.com/graphics/2021-palm-oil-deforestation-climate-change/

in enabling authorities to ensure commitments are being adhered to. The EU have committed to protecting and restoring the world's forests and in a 2019 communication explicitly stated that they will "*explore strengthened use of the Copernicus satellite system for forest monitoring*."[73] This case shows the true power of what Sentinels are capable of when it comes to the monitoring of deforestation. Regulatory benefits are further realised in relation to the complex decisions around the Renewable Energy Directive (RED II). As indicated in the discussion presented in chapter 4, many countries have taken steps towards phasing out biofuel relying on palm oil – but the public debate on this is still raging[74]. What cannot be disputed, however, is that having objective evidence of the impact of palm oil production on indirect land use change is a necessary requirement to inform this public debate. And this precisely what the Sentinel-enabled service of Satelligence offers.

- Better monitoring and enforcement sustainability commitments (tier 2)

5.3.4 Entrepreneurship & Innovation

Satelligence have contributed greatly to the entrepreneurship and innovation landscape with the development of their deforestation monitoring service. Although not the only service of its kind, the huge food industry players who utilise Satelligence's service are a testament to the service's value. As already stated, thanks to the service's strong proposition, Satelligence recently managed to become the first remote sensing company to have its deforestation monitoring services assured by a big four accounting firm. By working closely with Satelligence and championing the use of remote sensing in forest monitoring, Bunge too are helping to steer the future of the innovation landscape towards more development of remote sensing-powered technologies for the food industry.

- Creation of innovative services (tier 1)
- Championing of innovative services and changing of operational practices (tier 2)

5.3.5 Science and Technology

Satelligence contribute to the scientific landscape with their participation in the RADD initiative. This publicly available system, developed alongside Wageningen University went live through the Global Forest Watch and provides insights on deforestation using Sentinel-1 data. Through the development of the system, new remote sensing detection methods[75] have been contributed to the scientific and technological landscape.

[73] https://ec.europa.eu/info/publications/eu-communication-2019-stepping-eu-action-protect-and-restore-worlds-forests_en

[74] See for instance: https://www.etipbioenergy.eu/sustainability/palm-oil

[75] https://iopscience.iop.org/article/10.1088/1748-9326/abd0a8/pdf

- Contribution to the development of new remote sensing techiques for the detection of deforestation (tier 1)

5.3.6 Societal

In this case, rural communities in Malaysia and Indonesia avoid being exploited for the use of their lands and are less likely to work for unethical palm oil producers. The use of services such as the one in this case also helps to raise the visibility of issues associated with palm oil and therefore helps in influencing citizens and society to be more conscious of what they are consuming. The transparency with which services such as this operate undoubtedly contributes to a greater sense of social cohesion amongst rural communities. Local workers are empowered with a sense of purpose and a shared understanding in the fight against environmentally damaging practices within their communities.

- Protection of rural communities and fighting against resource exploitation (tiers 1, 2, 3 and 4)
- Social cohesion and shared understanding of the challenges being faced (tiers 3 and 4)

5.4 Synoptic overview

Having looked at the different types of benefits and before proceeding to the conclusions extracted in this study it is instructive to provide a synoptic overview in the table below.

Tier	Benefits identified	Type	Value where economic[76] (annual)
Tier 1 (Satelligence)	**Revenue** linked to the use of Sentinel data	Economic	€ 1.5 – 6.3 million
	Production and utilization of **deforestation-free palm oil**	Environmental	
	Production and utilization of **deforestation-free palm oil**	Environmental	
	Maintenance of **peatland and sequestration of CO_2**	Environmental	
	Providing monitoring services for **socially conscious operations**	Societal	
	Creation of innovative services	Entrepreneurship and innovation	
	Development of new remote sensing-based deforestation techniques	Science and Technology	
	Protection of **rural communities and fighting against resource exploitation**	Societal	

[76] The ranges indicate current (2021) and projected (2026) economic benefits

Tier 2 (Bunge)	**Access to favorable interest rates** on sustainability-linked loans	Economic	€ 5 million
	Production and utilization of **deforestation-free palm oil**	Environmental	
	Maintenance of **natural habitats and ecosystems**	Environmental	
	Maintenance of **peatland and sequestration of CO_2**	Environmental	
	Protection of **rural communities and fighting against resource exploitation**	Societal	
	Championing of **innovative services** and **changing of operational practices**	Entrepreneurship and innovation	
	Better **monitoring and enforcement sustainability commitments**	Regulatory	
Tier 3 (Suppliers and customers of Bunge)	**Premium pricing** for certified sustainable palm oil products	Economic	€ 12.5 – 22.3 million
	Production and utilization of **deforestation-free palm oil**	Environmental	
	Maintenance of **natural habitats and ecosystems**	Environmental	
	Maintenance of **peatland and sequestration of CO_2**	Environmental	
	Protection of **rural communities and fighting against resource exploitation**	Societal	
	Social cohesion and **shared understanding of the challenges being faced**	Societal	
Tier 4 (Citizens and Society)	Production and utilization of **deforestation-free palm oil**	Environmental	
	Maintenance of **natural habitats and ecosystems**	Environmental	
	Maintenance of **peatland and sequestration of CO_2**	Environmental	
	Protection of **rural communities and fighting against resource exploitation**	Societal	
	Social cohesion and **shared understanding of the challenges being faced**	Societal	
TOTALS			**€ 19 – 33.6 million**

Table 5-3: Summary of benefits for each Tier

6 Key Findings and Final Thoughts

6.1 Key findings

In studying this case, it became clear that **when large industry players such as Bunge commit to sustainability in their operations, they act as catalysts for the entire value chain to reduce its**

environmental impact, both upstream and downstream. It is no exaggeration to say that **Sentinel data is truly the key to Bunge being able to monitor and verify that the palm oil it sources and provides to actors downstream is not having a detrimental effect on ecosystems and rural communities**, especially when it comes to deforestation and its consequences. In that regard, the standout benefits in this case relate to the environmental dimension. And it comes as no surprise that these environmental benefits are associated with very sizeable economic ones too. And when the environment and the economy as so intricately connected, regulation is also strongly present as has been seen in this case. Finally, since the use of Sentinel-enabled services for supply chain monitoring represents a paradigm shift for the involved companies, its impact on innovation, entrepreneurship, science and technology is also considerable. This is summarise in the graph below.

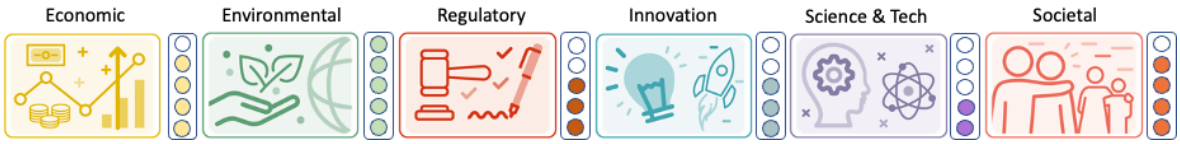


Figure 6-1: Delivering value across the full range of dimensions

In our analysis, we have focussed on the exemplary partnership between Satelligence and Bunge, focusing on palm oil, primarily in Malaysia and Indonesia. However, very similar considerations (economic, environmental, regulatory and societal) have been driving the uptake of Sentinel-enabled services by more actors in the palm oil industry but also in relation to other agricultural commodities such as cocoa, soya and beef. **This means that the overall economic value of Sentinels in relation to deforestation free agricultural commodities supply chains is much larger than the €19 - 33.6 million reported here, with the same applying to all other dimensions of benefit too.** This wider perspective is discussed in greater detail, but before that we provide an account of the impact of Sentinel data and the issue of attributing a value to this impact.

6.2 The Impact of Sentinel Data

In most cases analysed under the *Sentinel Benefits Study* the question of attribution arises, i.e. what part (or percentage for the economic value) of the produced benefit can be attributed to the use of Sentinel data? In the case of deforestation monitoring for palm oil production, the answer to this question seems straightforward – 100%! The ability of Bunge to verify deforestation free palm oil production heavily relies on the alerts provided by Satelligence, which in turn are generated through a Sentinel-based service. This means that Bunge can prove its adherence to sustainability commitments to its investors and thus benefit from advantageous interest rates for its sustainability-linked loan. Similarly, for suppliers (plantations and mills) to benefit from selling certified sustainable palm oil, they need to prove no deforestation has occurred. Which is where the service of Satelligence comes in.

Where attribution becomes more complex is when we consider multi-parametric aspects such as company reputation. As discussed in chapter 5, there is no doubt that proving deforestation-free palm oil at production, refinement, trading, or consumer product level, helps those companies

involved in these processes to maintain a good reputation. However, this reputation is linked with several other aspects within the ESG framework. Therefore, we have refrained from assigning a value to this type of benefit traced down to the use of Sentinel data as the uncertainty for this would be too high. Similarly, whilst Sentinel-based deforestation monitoring services are a key enabler for the realisation of environmental benefits, it really comes down to the involved actors to undertake the necessary actions. In other words, Satelligence might spot illegal deforestation cases, but unless the companies and governments involved act to stop it, no environmental benefit is realised.

6.3 Widening the Perspective

The main focus of this case has been the use of optical and radar data to detect deforestation in Southeast Asia. The application, however, of the technique used is by no means specific to this region. Instead, it has a much wider perspective. This can be studied along three dimensions: (i) geographic extension, (ii) increased market penetration and (iii) improved technological maturity. Below we discuss these dimensions in the context of this case

- **Geographic Extension**

It is obvious that the service discussed in this case lends itself to increased geographic coverage. Any other parts of the world in which palm oil is cultivated are ideal candidates for geographic extension. These not only include other parts of Southeast Asia such as Thailand, Cambodia, and Vietnam, but large parts of Central and Sub-Saharan Africa as well as Central and South America. Ignoring the administrative and bureaucratic barriers to providing services in other parts of the world, the technical barriers to entry are relatively low. Given the global coverage of the Sentinels, some "tuning" of the deforestation detection algorithms would be required for new regions as each area on the globe is different in terms of forest types and deforestation practices. Nevertheless, this is something that Satelligence are already doing and extending coverage to other parts of the world has already begun; as mentioned, they have offices in Ghana and Bolivia specifically to help in this endeavour.

- **Increased Market Penetration**

There is strong potential for increased uptake of this type of deforestation monitoring service within the agri-food industry. More and more players in the market are becoming conscious of their environmental footprint, more regulations are being imposed on corporate actors to abide by environmentally friendly rules, more financial incentives are being given to stakeholders in the supply chain to commit to sustainable practices and more customers are demanding transparency in how the food they eat is produced. All of these forces are driving the demand for the types of service discussed in this case. Satelligence are relatively early innovators in this field and Bunge are relatively early adopters of this type of service, as time goes on adoption of sustainability monitoring services will likely only increase. As already discussed, the service is not only relevant to the monitoring of deforestation related to palm oil, but also to deforestation related to the

production of cocoa, soya and beef, meaning huge potential lies applying the service in many commodity markets in the future.

- **Improved Technological Maturity**

Several improvements are possible for this type of service, such as increased accuracy of detection along with smarter and wider detection capabilities across different types of forest, terrain, and commodity. As already discussed, Satelligence are also looking into marrying the deforestation monitoring service with other supply chain monitoring services and blockchain technology to create extremely robust and holistic food supply chain sustainability monitoring services.

6.4 Final Thoughts

This case has undoubtedly been one of the richest in terms of depth that we have studied in the Sentinel Benefits study. The importance of the Sentinel-enabled deforestation monitoring for sustainable palm oil production offered by Satelligence has been underlined throughout the case, as have the benefits associated with the use of this service by Bunge. In several points of the analysis, we have come across areas that would deserve further study. This includes the considerations around stranded assets and a robust methodology to measure the impact that the alerts provided by Satelligence have to that. It also includes the attribution of company reputation value back to the use of satellite-based services. Finally, it concerns the associated environmental and societal benefits both of which would benefit from complementary studies. As a final thought, we consider this case an excellent example of the strength of Sentinel data in supporting the achievement of sustainability goals in major supply chains. This example, realised thanks to Bunge and Satelligence, should be replicated and extended within that sector and beyond.

Annex 1: References and Sources

1. Roundtable on Sustainable Palm Oil - homepage: https://rspo.org/
2. Bunge – Sustainability Policy: https://www.bunge.com/sustainability/palm-oil-sourcing-policy
3. Bunge – Sustainability linked credit facility text: https://otp.investis.com/clients/us/bunge/SEC/sec-show.aspx?FilingId=13797039&Cik=0001144519&Type=PDF&hasPdf=1

Annex 2: General Approach and Methodology

This case has been analysed as a part of the Sentinel Benefits Study (SeBS), which looks at the value being created by the use of Sentinel data. It follows a methodology[77], established during a previous study, looking at a value chain for the use of a single EO service.

For each case, a value chain is established with a service provider and a primary user. The value-chain is validated with these two key players. Through a combination of desk and field research, we develop our understanding of all the actors in the value chain, the role that they play and how they may benefit through the use of the satellite-derived products.

The value-chain is divided into a number of tiers where the supplier is Tier 1, and the primary user is Tier 2. The last Tier is always "Citizens and Society". The number may vary according to the complexity of the value-chain. The benefits are then analysed against each of these tiers.

Once written, the draft report is then shared with all the persons with whom we have spoken, and their comments are incorporated, or a further discussion is held to establish a common understanding. Note that we are not asking these experts to endorse our findings but to indicate any gross errors or sensitivities which may have been introduced. At the end of this process, the report is made public.

As work has proceeded and more cases analysed, some modifications have been made to the methodology described in reference 77. The first of these has been to expand from the two dimensions used earlier, namely economic and environmental benefits, to add those connected to societal, regulatory, innovation and entrepreneurship and scientific and technological. These six dimensions are described in the table A2-1 below.

Dimension	Definition
ECONOMIC	Impacts related to the production of goods or services, or impacts on monetary flow or volume, such as revenue, profit, capital and (indirectly, through turnover generation) employment.
ENVIRONMENTAL	Impacts related to the state and health of the environment, particularly as regards the ecosystem services on which human societies depend.
SOCIETAL	Impacts related to societal aspects such as increased trust in authorities, better public health or secured geostrategic position.
REGULATORY	Impacts linked to the development, enactment or enforcement of regulations, directives and other legal instruments by policymakers.
INNOVATION-ENTREPRENEURSHIP	Impacts linked to the development of new enterprise and/or the introduction of technological innovation into the market.
SCIENCE-TECHNOLOGY	Impacts linked to academic, scientific or technological research and development, the advancement of the state of knowledge in a particular domain.

Table A2-1: Definitions for the benefit dimensions

[77] SeBS Methodology; June 2017.

For each of these, a ranking has been introduced to give an immediate, visual impression of the scale of the benefits under each dimension. To aid in the quantification of these, a guide has been introduced which is shown in Table A2-2.

Rank	Benefit status	Criteria
0	**Null**	The case presents no perceivable benefits in this dimension, and no potential for such benefits to emerge is anticipated.
1	**Latent**	The value chain described in the case may, in general, present potential benefits in this dimension, but none have been identified or described in this particular instance.
2	**Manifest**: At least one benefit in this dimension has been identified through the value chain within the case. Its significance in the context of the case overall is judged to be:	**Low**
3		**Moderate**
4		**High**
5		**Exceptional**

Table A2-2: The ranking of the benefits.

In order to introduce further basis for comparison, a systematic approach has been developed for the analysis of the benefits. A series of indicators have been defined for each of the benefit dimensions against which each case can be considered.

The indicators used in the case are listed in chapter 5, and a full list of all indicators considered is provided in Table A2-3.

Dimension	Indicator	What it can mean.
Economic	Avoided costs (AV)	Alternative means to gather data
	Increased Revenues (IR)	Increased production/sales
	Reduced Inputs (RI)	Less time spent or material saved
	Improved Efficiency (IE)	Better use of resources
Environmental	Reduced pollution (RP)	Reduced amounts of pollutants in key resources e.g. water, air
	Reduced impact on natural resources (RR)	Reduced environmental impact e.g erosion, habitats/biodiversity.
Societal	Improved public health (IPH)	Less toxicological risk
	Common Understanding (CU)	Better control and communication of remedial efforts i.e through common maps.
	Increased trust and better transparency (ITT)	Improved preparedness / response
	Strategic Value (SV)	Common societal value to a country or region.
Regulatory	Improved policy / regulation design/drafting	Better information (scale, accuracy) leading to better regulation
	Improved efficiency in policy/regulation monitoring	Better information available to monitor adherence to regulations.
Innovation & Entrepreneurship	Innovative products	Sentinel data leads to creation of new products / services
	New Business models	New ways to generate income.
	New markets	Global nature of sentinel data enables international business development
	New businesses	Creation of new companies; start-ups
Science & technology	Academic output	
	Research exploitation	Applied science to operational services
	Research contribution	New product enabling scientific research

Table A2-3: Complete list of indicators considered within SeBS analyses.

Annex 3: About the Authors

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Lefteris is a strategy consultant with solid knowledge of programmatic, strategic and business aspects of EU Space Programmes (Copernicus and Galileo). In the past 10 years, Lefteris has been extensively involved in various studies and projects related to the development, market uptake and exploitation of EO downstream applications. He has been advising clients and partners across the full spectrum of the EO value chain, including EU institutions (EC, EEA, SatCen, ESA), universities and private companies.
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Dáire is a consultant with the Brussels-based consultancy Evenflow, who work in collaboration with EARSC on the Sentinel Benefits Study (SeBS). Dáire worked as an engineer for a large upstream oil & gas company in Aberdeen, Scotland for 4 years before moving to Belgium to complete a masters in International Business Economics & Management. Dáire has extensive root cause analysis and statistical analysis skills developed through both his professional and academic career. He currently acts as exploitation manager for the H2020 CYBELE project.

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