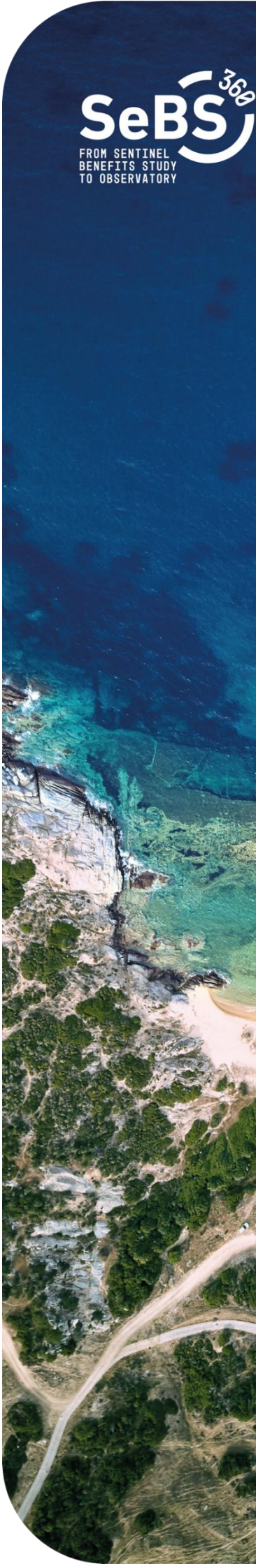
SeBS 360
FROM SENTINEL BENEFITS STUDY TO OBSERVATORY

EUDR compliance for cocoa sourcing in Ivory Coast

Case Study

July 2026



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Setting the Scene

Adama sat under the kola tree at the edge of his cocoa farm, the afternoon sun already softening, and watched the line of pickup trucks rumble out of the cooperative's drying yard toward the regional buying station in San-Pédro. The harvest was good this year. Could have been better, but hey, that's farmers life for you.

That morning, the cooperative president had news for the weekly meeting. The Geneva buyer they had supplied for the past three seasons had been plain about it: this year's deliveries would be accepted only if every farm in the cooperative could be verified deforestation-free against the 31 December 2020, the new European regulation kicked in, it seems. And they use satellites to check this, oh how times have changed since he was a little kid helping his parents in the plantations.

Two other cooperatives in the sub-prefecture had not been able to meet the verification standard in time and had lost their buyer this season. His cooperative had met it. What worried Adama, even on a day like this, was what lay beyond the cooperative boundary. in the neighbouring areas, in the parcels his cooperative did not manage, forest clearance had eaten into the forest in patches over the past two years. From a satellite far above, he sometimes wondered, how could anyone tell with certainty where his neighbour's failure ended and his own success began? He had heard stories of farms in other cantons that had been flagged in error simply because the clearance around them had crept too close to an invisible line.

Adama's granddaughter Aminata, home from school in Abidjan for the holidays, appeared beside him with two glasses of bissap and a question in mind. She had been

wondering for days about the satellite story she had heard from a visitor to the cooperative the week before. "Grandfather, how does the buyer know that your farm has no forest cleared after 2020? Did someone come to measure it?"

Adama smiled. "Someone came, yes. A man with a tablet. He showed me satellite pictures of every farm in our cooperative. He even showed me the corner of our plot where I planted the new shade trees five summers ago, the ones the cooperative gave us at the start of the agroforestry programme. The satellite saw them."

Aminata took the satellite seriously. "So, the satellite is watching all the time?"

"Yes, the man said. The same satellite, the same eye, all the way back to before the regulation was written. The buyers trust the satellite more than they trust any paperwork I could send them. And because the satellite trusts our farm, the buyer trusts our farm, and we can sell."

She thought about that for a while. "And if the trees you planted die? Or if somebody cuts down trees on the other side of the road?"

Adama looked at her closely. The question was sharper than he had expected. "Then the satellite will see that too," he said. "Which is why we keep planting, and why we keep our boundaries clear. The hardest part is not the satellite. The hardest part is making sure that we are true to our land, and the rest will sort itself out."

Aminata fell quiet. The thought of satellites watching her grandfather's farm with such patience had been growing in her since the visitor's tablet. She had not yet decided what she wanted to study after school, but satellites observing Earth, she had begun to suspect, would be it.

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

Executive Summary

This case examines how Copernicus Sentinel data supports compliance with the EU Deforestation Regulation (EUDR) for cocoa sourced from Ivory Coast. EUDR, applicable from 30 December 2026 for large and medium operators and from 30 June 2027 for micro and small operators, requires operators placing cocoa on the EU market to submit dated, polygon-level evidence that the cocoa originates from land not deforested or degraded after 31 December 2020 and complies with the legislation of the country of production. The case examines a three-actor service chain (Disaitek, So-B-Green, and Africao Trading SA) that has built operational EUDR-compliance infrastructure in Ivory Coast around Sentinel-1 synthetic aperture radar (SAR) data, ahead of the regulatory enforcement window.

Ivory Coast is the world's leading cocoa producer, accounting with Ghana for around 46% of global cocoa output. Cocoa represents approximately 15% of GDP and 39% of national export income and supports the livelihoods of an estimated one million smallholder farmers and around two-thirds of the active population. Cocoa production is also one of the main drivers of deforestation in the country: Ivory Coast has lost more than 80% of its forest cover since 1960, cocoa cultivation is associated with over 37% of forest loss in protected areas, and around 35 to 40% of Ivorian cocoa is estimated to come from illegal cultivation in classified forests. EUDR is the regulatory response to the demand-side share of this dynamic, and Ivory Coast is one of the most exposed geographies in the regulation's scope.

The case examines a value chain operating across four tiers. At Tier 1, Disaitek, a France-based AI and Earth Observation company, processes **Sentinel-1 SAR data to produce parcel-level deforestation-status evidence against the EUDR cut-off date through different service modules**. At Tier 2, So-B-Green, a France-based sustainability consultancy operating in Côte d'Ivoire and Ghana, **integrates this satellite evidence into a seven-step EUDR workflow across approximately 133,600 hectares with 63,000 farmers enrolled in compliance programmes**. At Tier 3, Africao Trading SA, a Geneva-headquartered commodity trader, **uses the compliance evidence chain to maintain audit-ready EU market access for cocoa** primarily sourced from Ivory Coast. At Tier 4, the benefits flow to Ivorian smallholders who retain plot-level **market access through verifiable evidence rather than face precautionary supply retraction, to communities embedded in cooperative-governance structures, and to EU end consumers who can act on personal principles against forest-destruction goods through normal purchases.**

At the level of the technical compliance product, the **attribution to Sentinel data approaches 100%**. Sentinel-1 is the only satellite mission that provides a free, globally available C-band SAR archive with sufficient depth to date land-use change against the 31 December 2020 cut-off, and field-based or optical-only verification cannot meet the EUDR burden of proof at the smallholder scale and cocoa-market price point the regulation has to operate within.

Attribution becomes more graduated downstream, where the satellite layer underpins compliance and reaches but the operational, commercial, and societal outcomes also rest on actor-driven capabilities.

The case demonstrates a qualitative shift from traceability towards verifiability in commodity supply-chain compliance and shows that the same Sentinel-anchored evidence can travel across the wider EU sustainability regulatory policy stack, beyond EUDR itself. It also documents an SME-led pattern: the verifiability infrastructure was built bottom-up by a small EO company, a regional field operator, and a single cocoa trader, rather than top-down by incumbent traders or platform providers. The Sentinel-1 layer is the technical foundation that makes this entire compliance architecture economically viable at the scale EUDR requires.

1 Introduction and Scope

1.1 The Context of this study

The analysis of the case study 'EUDR compliance for cocoa sourcing in Ivory Coast' is carried out in the context of the Sentinel Benefits Observatory (SeBS360), an activity of the European Space Agency that builds on and extends the long-running Sentinel Benefits Study (SeBS). SeBS has produced a foundational methodology[1], and a portfolio of case studies documenting how Earth Observation services based on Copernicus Sentinel data deliver value across the value chain to users, society, and the wider economy. The SeBS360 project continues the case-study work and adds a programme-level synthesis layer aimed at extracting sectoral synopsis-type insights found in the benefit patterns the Sentinels generate across sectors and geographies.

The Sentinels form a central part of the European Union's Copernicus Programme, providing space-based observations on a full, free, and open basis. 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. Data from the Sentinel missions, together with other relevant data sources and complementary information, support a wide range of application areas, including agriculture, forestry, climate monitoring, environmental protection, disaster risk management, and natural resource management. Sentinel data therefore constitutes a key input for the development of downstream products and services delivered by companies and organisations to users in Europe and beyond.

1.2 What is the case all about?

Agricultural supply chains exposed to comprehensive environmental regulations require monitoring methods that can verify land-use history and support timely compliance decisions. This is especially important for high-value import commodities like cocoa, where cultivation is often distributed across thousands of smallholder plots in tropical regions rather than consolidated in large industrial estates.

In this context, the **present case examines how satellite-based synthetic aperture radar time-series analysis is used in Ivory Coast to support compliance of the local cocoa farming with the European Union Deforestation Regulation** (EUDR[2]), with the

[1] The previous Sentinel Benefits Study project produced a foundational methodology for the assessment of the impact and benefits the Sentinels have on various aspects of industry, science and society. The methodology is available on the following link: https://sebs360.eu/wp-content/uploads/2026/03/SeBS-Methodology-2024.pdf

[2] Regulation (EU) 2023/1115 of the European Parliament and of the Council of 31 May 2023 on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation. Available at: https://eur-lex.europa.eu/eli/reg/2023/1115/oj

enforcement of the regulation for large operators expected to begin by the end of 2026. In the technical context of the case, Disaitek, a France-based downstream service provider, provides the Machine Learning (ML) / Artificial Intelligence (AI)-powered, satellite-based monitoring capability, while So-B-Green, a France-based sustainability consulting firm with offices in Côte d'Ivoire and Ghana, integrates this information into an operational workflow that includes traceability, compliance assessment, field verification, and resilience-building activities. This reflects a broader **pattern in which remote sensing is combined with *in situ* validation, to support decision-making and targeted action for EUDR-compliant cocoa farming**. Cooperation between Disaitek and So-B-Green extends beyond operational services aimed at regulation compliance, into innovation-oriented work in the cocoa sector, including the application of the developed capabilities to support agroforestry uptake and forest restoration activities, as well as several ongoing initiatives oriented towards corporate sustainability reporting. This broader relationship also has a clearer timeline: So-B-Green and Disaitek first joined forces in 2023, initially around agroforestry needs and support for compliance with the European anti-deforestation regulation, before extending their collaboration to other cocoa-and-forest applications. Africao Trading SA (hereinafter Africao) a Switzerland-based commodity merchant sourcing cocoa, coffee, and speciality products from Latin America and Africa, with a strong presence in Ivory Coast, in turn relies on this validated compliance ecosystem to support regulatory readiness and continued market access, while broader benefits extend to citizens and the society at large through reduced deforestation risk and support for more sustainable smallholder integration into international supply chains.

Figure 1 Cocoa plantation. Source: World Cocoa Foundation

1.3 More about the study

Each case study developed under **SeBS360** focuses on products and services that use data coming from Sentinel satellites and examines how the resulting value is generated across the value chain. The analysis starts from the direct use of Sentinel-derived information by the relevant actors in the case and then follows the subsequent links in the chain in order to understand how benefits extend beyond the immediate user to other organisations, market actors, and ultimately citizens and society. In the present case, this also requires attention to the interaction between satellite-derived outputs and field-based processes, because the service is used not in isolation but as part of a broader compliance and sourcing workflow. Comparable work in related cocoa-and-forest contexts shows that the value of EO-based information is most useful when it is integrated with *in situ* evidence and used to support differentiated risk assessment and action. In broader partnership work analysed in the study, this has taken the form of combining satellite-based analysis with socio-economic and ecological fieldwork to generate decision-relevant evidence.

In this process, the main aim is to understand and demonstrate the value generated through satellite-based EO, and in particular, using data from the Copernicus Sentinel missions. The case study, therefore, seeks to trace the link between the use of Sentinel data and the benefits that arise from that use, and to attribute those benefits to Sentinel data as far as the evidence allows. These benefits may include, among others, improved operational efficiency, stronger traceability, better-informed decision-making, reduced uncertainty, regulatory compliance, economic gains, environmental protection, and wider societal value. These benefits are shaped not only by the technical properties of the EO service itself, but also by the extent to which it is integrated into operational practice, including traceability systems, field verification, and decision-making processes.

The evidence generated through these case studies can be useful to a variety of interest groups. For **decision-makers**, access to a portfolio of concrete and well-documented cases helps demonstrate where and how Sentinel data creates practical value, thereby supporting future investment and policy decisions. For **users**, such case studies move beyond a general understanding of EO and provide clearer evidence of what EO-based services can contribute in comparable operational settings. For **service providers**, comprehensive evidence on the benefits associated with Sentinel-enabled services can strengthen communication, market positioning, and the broader promotion of EO-based solutions.

Within the framework of **SeBS360**, multiple case studies are being developed and documented to strengthen the evidence base on how Sentinel data supports operational

activities, generates value across different sectors, and delivers benefits that extend beyond immediate users.

1.4 Acknowledgements

Producing this case study report would have been impossible without the invaluable insights and kind assistance of key stakeholders. They helped us navigate across the various aspects of their business activities with the specific contexts of their value chains, as well as build an understanding the intricacies and realities of this sector. **The will of users and stakeholders to collaborate and enrich this study, enables a very practical and transparent analysis of the actual value that Sentinels add**.

Following this, **we would like to extend special thanks** to:

- Anthony Graveline - Disaitek
- Charles Tellier – So-B-Green
- Delphine Pernot – So-B-Green
- Dean Tutić – Africao

2 EUDR Compliance for Cocoa Sourcing in Ivory Coast Overview

2.1 Deforestation risk and agricultural exposure in Ivory Coast

Ivory Coast's agricultural economy makes forest degradation a structural supply-chain issue rather than an occasional local anomaly. The country is the world's leading producer of cocoa, accounting with Ghana for 46% of global cocoa[3]. **In Ivory Coast, around 39% of the country's export income is generated by cocoa**, and approximately 15% of the GDP comes from cocoa. Approximately two-thirds of the active population of Ivory Coast, including **1 million smallholder farmers, depend on cocoa for their livelihood**[4]. Cocoa is also an important source of income for millions of people worldwide. The four leading exporting countries are Ivory Coast, Ghana, Ecuador, and Cameroon. **Cocoa production in many countries is linked to environmental and social risks**, including deforestation, forest degradation, child labour, and low incomes for smallholder farmers[5]. From the demand side, the EU accounts for 60% of global cocoa imports[6][7]. As the EU has increasingly strengthened its requirements for supply chain transparency and sustainability in the agri-food sectors, notably with EUDR, the need for traceability of exported products has also heightened in producing countries.

Cocoa cultivation has been identified as an important driver of deforestation worldwide. In Ivory Coast, the high rates of forest degradation and loss reflect a combination of factors, such as declining soil fertility, falling yields, migration, low enforcement success, corruption, limited financial resources, and political instability. Cocoa is a commodity that has historically driven significant land-use change, forest encroachment, and biodiversity loss, contributing to the loss of over 80% of its forest

[3] The Swiss Platform for Sustainable Cocoa (Kakaoplattform) is a multi-stakeholder initiative bringing together the Swiss cocoa sector, public authorities, civil society and research institutions to advance sustainability in cocoa supply chains. The cited combined share of Côte d'Ivoire and Ghana in global cocoa production is drawn from the platform's Cocoa Facts and Figures page. Available at: https://www.kakaoplattform.ch/about-cocoa/cocoa-facts-and-figures

[4] Kouassi, J.-L., Diby, L., Konan, D., Kouassi, A., Bene, Y. and Kouamé, C., 2023. "Drivers of cocoa agroforestry adoption by smallholder farmers around the Taï National Park in southwestern Côte d'Ivoire." Scientific Reports, 13, 14309.

[5] SEPAL (System for Earth Observation Data Access, Processing and Analysis for Land Monitoring) is the Food and Agriculture Organization's open-source remote-sensing platform supporting natural-resource monitoring at country level, with a dedicated workstream on sustainable cocoa value chains. Available at: https://www.fao.org/in-action/sepal/activities/cocoa/en

[6] European Commission press release IP/21/193 of 21 January 2021, "EU boosts sustainable cocoa production in Côte d'Ivoire, Ghana and Cameroon", announcing a €25 million EU contribution to enhance the economic, social and environmental sustainability of cocoa production in the three producing countries. Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_21_193

[7] Boysen, O. (2025). The Impact of the EU Deforestation Regulation on Cocoa: Markets, Trade and Forest Conservation. JRC Working Papers on Economic Analysis of Policies in Africa, July 2025. European Commission, Joint Research Centre, JRC141600. https://publications.jrc.ec.europa.eu/repository/handle/JRC141600

cover since 1960[8]. Kalischek et al (2023) showed that in protected areas of Ivory Coast, over 37% of forest loss has cocoa cultivation as the underlying driver [9].

Around 35–40% of Ivory Coast's cocoa crop comes from illegal cultivation in protected forest areas[10]. In practice, this means that deforestation is deeply intertwined with the rural economy, forming part of the wider risk landscape within which commodity buyers, traders, and sustainability consultants must operate[11].

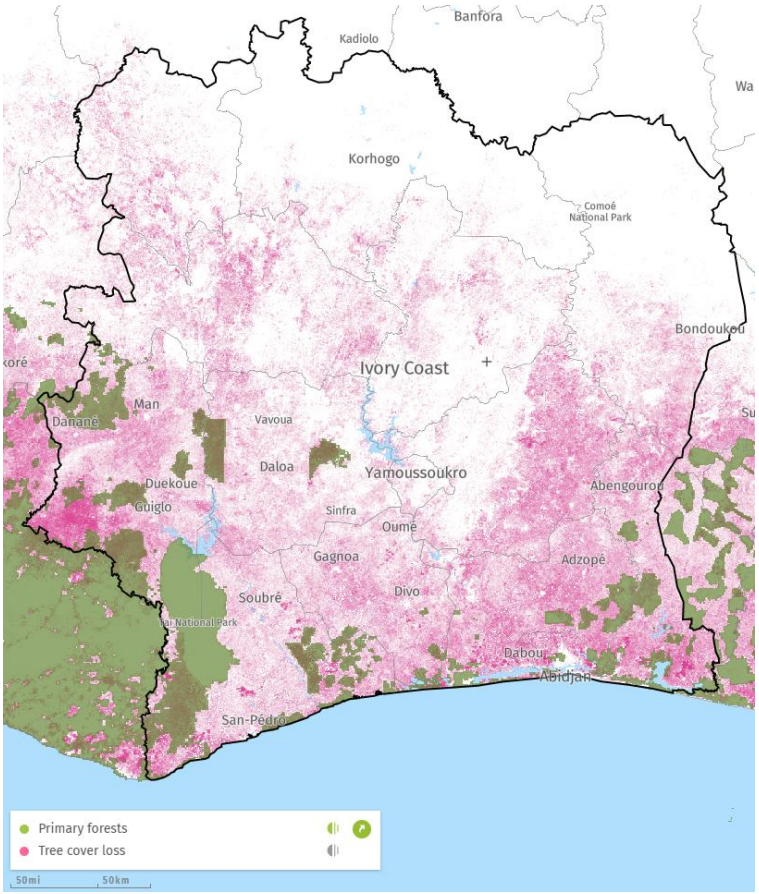

Figure 2 Primary forests and tree cover loss in Cote d'Ivoire[12]

[8] Renier, C., Vandromme, M., Meyfroidt, P., Ribeiro, V., Kalischek, N. and Zu Ermgassen, E.K.H., 2023. "Transparency, traceability and deforestation in the Ivorian cocoa supply chain." Environmental Research Letters, 18(2), 024030.

[9] Kalischek, N., Lang, N., Renier, C., Daudt, R.C., Addoah, T., Thompson, W., Blaser-Hart, W.J., Garrett, R., Schindler, K. and Wegner, J.D., 2023. "Cocoa plantations are associated with deforestation in Côte d'Ivoire and Ghana." Nature Food, 4(5), 384–393.

[10] Earthworm Foundation, Cavally Forest Reserve project — a multi-stakeholder initiative addressing deforestation pressure in the Cavally region of Côte d'Ivoire, including the reported estimate that 35-40% of Ivorian cocoa is produced through illegal cultivation in classified forests and protected areas. Available at: https://earthworm.org/news-stories/cavally-easepressureonforests

[11] The Guardian, 13 September 2017. "Chocolate industry drives rainforest disaster in Ivory Coast." Investigative news article reporting on cocoa-driven deforestation in Côte d'Ivoire, including the estimate that the country has lost more than 80% of its forest cover since 1960 and the implication of major cocoa buyers in the supply chains feeding the destruction. Available at: https://www.theguardian.com/environment/2017/sep/13/chocolate-industry-drives-rainforest-disaster-in-ivory-coast

[12] Global Forest Watch country dashboard for Côte d'Ivoire, an open-access platform maintained by the World Resources Institute providing satellite-derived data on tree cover loss, primary forest extent and forest dynamics at

Cocoa monoculture simplifies the landscape by replacing diverse plant cover with a single crop, which can weaken soil quality, reduce habitat diversity and connectivity, impact biodiversity, and intensify pressure on water and other natural systems. Monocropping often involves a heavy use of harmful pesticides, fungicides, and other chemicals, which pollute water systems as well as endanger many species[13]. Despite these negative impacts, farmers are driven to these techniques nonetheless due to variable yields, high input and labour costs, weed and disease pressure, land scarcity, and tree-tenure constraints, making simplified systems more manageable in the short term[4]. Farmers use monoculture or other intensive practices because cocoa prices often do not cover the costs of sustainable production. Indeed, cocoa income is also often needed to meet basic livelihood needs, which encourages farmers to prioritise short-term cash flow over long-term resilience[14]. In addition, low yields, ageing trees, weak farm maintenance, and pest and disease pressure make more diverse or low-input systems harder to sustain without support[4]. In some settings, farmers expand into forested areas because fertile soils and favourable microclimates can support cocoa growth and production[13]. The uptake of agroforestry, a practice with significant potential to mitigate the negative environmental effects of cocoa farming, can also expose farmers to additional risks without adequate governance. Cocoa agroforestry plots typically contain valuable timber species, which can attract illegal logging activity and require dedicated tree-tenure protection.

Cocoa-driven deforestation is therefore not only a farm-level issue but also a supply-chain problem rooted in rural livelihoods and market incentives. Land-use decisions are made by farmers, but they are shaped by prices, tenure conditions, labour availability, and policy support.[15]

country level. The figure on primary forests and tree cover loss in Côte d'Ivoire is drawn from this dashboard. Available at: https://www.globalforestwatch.org/dashboards/country/CIV/

[13] National Wildlife Federation, "Cocoa and Deforestation" — international programme overview by the U.S.-based conservation organisation, describing the environmental impacts of cocoa monoculture in West Africa, including biodiversity loss, habitat degradation, water-system pollution from agrochemical inputs, and pressure on natural systems in cocoa-producing regions. Available at: https://international.nwf.org/cocoa-and-deforestation/

[14] Welthungerhilfe (German Agro Action), "Why cocoa is still much too cheap" — feature article from the organisation's Global Food Journal examining the structural reasons why cocoa farm-gate prices fail to cover the costs of sustainable production, and the consequences for farmer livelihoods and land-use decisions. Available at: https://www.welthungerhilfe.org/global-food-journal/rubrics/business-human-rights/why-cocoa-ist-still-much-too-cheap

[15] Coral, C., Carcamo, R., Ollendorf, F., Tokou, B.A., Adou Yao, C.Y., Sieber, S. and Löhr, K., 2024. "Elongating the causes of social vulnerability: Historical analysis of social sustainability dimensions in the Ivorian cocoa sector." World Development, 183, 106746.

Ivory Coast's cocoa sector is embedded in a global supply chain (Figure 3) linking smallholders, intermediaries, processors, and international buyers, so **deforestation risk becomes a compliance issue that extends far beyond the farm level**.[16]

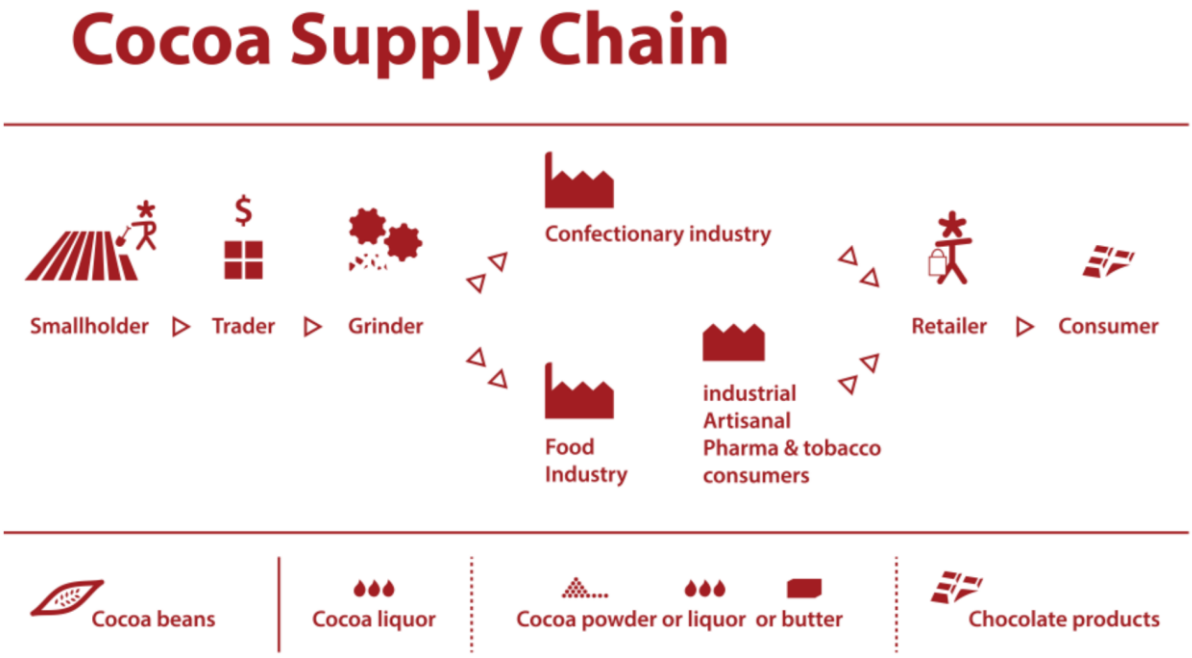

Figure 3 Cocoa supply chain[17](Note: "cocoa liquor" denotes cocoa paste, a thick mass produced from grounded and roasted cocoa nibs.)

The relevance of deforestation to the cocoa sector has been heightened by the introduction of the EU Deforestation Regulation (EUDR), which strictly prohibits companies from placing products on the EU market that originate from land deforested or degraded after 31 December 2020. This is important in this case because **the challenge is not simply whether a farm is sustainable today, but whether its historical land-use footprint over the past several years meets rigid, non-negotiable legal thresholds**. In practical terms, this means that operators placing cocoa on the EU market must be able to show that **the product does not originate from land deforested after 31 December 2020** and that it complies with the relevant legislation of the country of production[15]. Even if a specific cooperative is well-managed, cocoa sourced from

[16] Joint Research Centre (European Commission), 2025. "The Impact of the EU Deforestation Regulation on Cocoa — Markets, Trade and Forest Conservation." JRC Working Paper JRC141600, July 2025. Available at: https://publications.jrc.ec.europa.eu/repository/handle/JRC141600

[17] World Bank, 2017. "Eliminating Deforestation from the Cocoa Supply Chain", by Kroeger, A., Bakhtary, H., Haupt, F. and Streck, C. — World Bank report (document 115144, revised 30 May 2017), examining the structure of the cocoa supply chain, the role and limitations of certification schemes in reducing cocoa-linked deforestation, the deforestation-related commitments of cocoa companies across the value chain, and a vision for zero-deforestation cocoa drawing on lessons from the palm-oil sector. Available at: https://documents1.worldbank.org/curated/en/876071495118818649/pdf/115144-REVISED-20170530-Cocoa-final-updated.pdf

surrounding degraded areas can “contaminate” the supply chain, triggering import bans and severe financial penalties.

This broader context is especially relevant for fragmented, smallholder-dominated agriculture. Unlike large commercial plantations, cocoa in Ivory Coast is predominantly grown by individual farmers on plots frequently smaller than two hectares. In these circumstances, the monitoring problem becomes highly spatial and historical: compliance must be verified at the level of individual, geo-located polygons across complex agriculture and forestry landscapes.

The EUDR presents Ivory Coast’s cocoa sector with several implementation challenges. Many farmers and cooperatives still need more guidance on the regulation’s requirements, while national legal and forest-definition frameworks do not yet fully match EUDR expectations. Compliance also imposes significant costs, particularly for smaller firms and cooperatives, because it requires traceability, geolocation, documentation, and monitoring[18][19]. In addition, the sector still faces major traceability gaps, making farm-level verification difficult[20].

In that sense, the issue is less about any single technology provider than about how to document forest cover in a supply chain shaped by long-standing deforestation pressures.

2.2 Monitoring challenges in fragmented smallholder agriculture

Fragmented agricultural networks are inherently more difficult to monitor than consolidated commercial estates because they extend across vast, heterogeneous landscapes encompassing varying degrees of canopy cover, mixed cropping, and shifting land boundaries. In practical terms, this means that regulatory risk is distributed unevenly: one farmer’s plot may be fully compliant, while an adjacent plot may have gradually expanded into a protected forest reserve. **The operational challenge is**

[18] Agroberichten Buitenland, 30 July 2024. "Côte d'Ivoire's cocoa sector ready to combat deforestation." News article from the Dutch agricultural attaché network on the state of EUDR readiness across the Ivorian cocoa value chain. Available at: https://www.agroberichtenbuitenland.nl/actueel/nieuws/2024/07/30/as11-cote-divoires-cocoa-sector-ready-to-combat-deforestation

[19] Hamza Moluh Njoya, Sofía Cristóbal Reyes, Koumbo Alberic Hien, Franziska Ollendorf, Bonna Antoinette Tokou, Constant Yves Adou Yao, Stefan Sieber, Katharina Löhr, Can cooperative membership foster compliance with New European Union regulations on deforestation-free production? Evidence from cocoa farmers in Western Côte d'Ivoire, Trees, Forests and People, Volume 20, 2025, 100897, ISSN 2666-7193, https://doi.org/10.1016/j.tfp.2025.100897. (https://www.sciencedirect.com/science/article/pii/S2666719325001232)

[20] Reuters, 1 October 2024. "Cocoa traceability rates fail to improve as EU deforestation law looms." News article reporting on persistent traceability gaps in the cocoa supply chain ahead of EUDR application, including the difficulty of farm-level verification across smallholder networks in West Africa. Available at: https://www.reuters.com/markets/commodities/cocoa-traceability-rates-fail-improve-eu-deforestation-law-looms-2024-10-01/

therefore not only to map the farms, but to understand how land cover has changed over time across the entire sourcing perimeter.

This challenge becomes particularly acute in tropical environments like Ivory Coast due to persistent cloud cover. Relying solely on optical satellite imagery (such as Sentinel-2 or high-resolution commercial optical data) often yields fragmented or unusable historical records because critical periods of the year are obscured by clouds. If a deforestation event cannot be accurately dated because of a six-month gap in optical imagery, a buyer cannot definitively prove whether the clearing occurred before or after the EUDR's December 2020 cutoff date[21]. The challenge is intensified by the regulation's geolocation requirements, because **cocoa operators must be able to link commodities to specific sourcing areas and demonstrate deforestation-free status with verifiable spatial information**[22]. Utilisation of shade trees and similar agroforestry practices in cocoa farming (Figure 4) can significantly interfere with the ability of optical systems to differentiate between forest area and plantations, raising the uncertainty of ML models built entirely on passive sensor data.

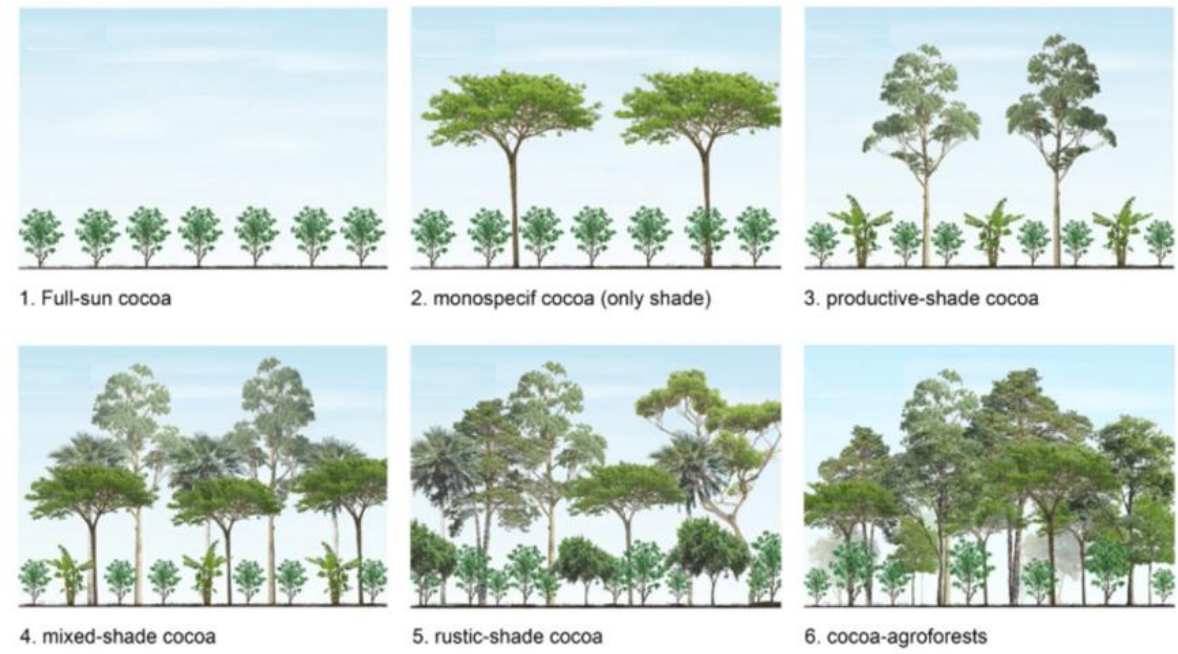

Figure 4 Different types of agricultural practices in cocoa farming - from a monoculture approach to agroforestry[23]

[21] Centre d'Études Spatiales de la Biosphère (CESBIO), CNRS, Multitemp research blog. "Benefits of SAR for forest loss alert detection in the tropics.". Available at: https://www.cesbio.cnrs.fr/multitemp/benefits-of-sar-for-forest-loss-alert-detection-in-the-tropics/

[22] Boysen, O., 2024. "The EU Deforestation Regulation and Cocoa: What's the Impact?" Paper hosted by the Inter-American Institute for Cooperation on Agriculture (IICA), August 2024. Available at: https://test-assets-opsaa.iica.int/storage/resource/2024/08/dc47010c577bfa98a7585361ee5cb644.pdf

[23] Orozco-Aguilar L, López-Sampson A, Leandro-Muñoz ME, Robiglio V, Reyes M, Bordeaux M, Sepúlveda N and Somarriba E (2021) Elucidating Pathways and Discourses Linking Cocoa Cultivation to Deforestation, Reforestation, and Tree Cover Change in Nicaragua and Peru. Front. Sustain. Food Syst. 5:635779. doi: 10.3389/fsufs.2021.635779

This forces operators into a lose-lose scenario: models are either too lenient, exposing the buyer to EU penalties and market exclusion, or too conservative, which damages the supply chain by unfairly excluding honest suppliers.

The monitoring problem is therefore not limited to identifying current forest boundaries; it involves maintaining an unbroken, highly reliable temporal record that can satisfy stringent European audit requirements**. For a consultancy like So-B-Green or a trader like Africao, relying only on field audits or incomplete optical data exposes the supply chain to unacceptable regulatory risk**. What is needed instead is a monitoring approach capable of providing a continuous and reliable temporal record, so that degradation events can be dated with sufficient confidence and the compliance status of large numbers of individual GNSS-delineated polygons (Figure 5) can be assessed consistently. In practice, the challenge is not only technical but also organisational, because compliance workflows must handle very large numbers of land parcels represented as delineated polygons while maintaining sufficient consistency and reliability to support sourcing decisions, traceability processes, and possible audit scrutiny.

Figure 5 Illustrative example of land parcels delineated as polygons. Each polygon represents a different farming area monitored under EUDR

2.3 Continuous monitoring as a compliance prerequisite

Deforestation monitoring for EUDR compliance requires understanding the land cover / land use dynamics over time. This type of information is economically unfeasible to acquire with conventional field inspections, and intermittently available optical imagery cannot provide it reliably. What matters in this context is not only the current condition of a plot, but whether its land-cover and land-use history can be reconstructed with sufficient confidence to support compliance decisions. **This makes continuity through time particularly important, because operators need to distinguish between temporary or seasonal variation and changes that indicate more permanent canopy loss**.

In fragmented smallholder landscapes, continuity also matters because compliance must be assessed across large numbers of individual plots rather than through isolated checks. A reliable temporal record makes it possible to move beyond one-off verification and towards a more systematic assessment of land-cover change over time. In this sense, **the key requirement is not simply broader coverage, but information that is comparable across dates and robust enough to support interpretation in a regulatory context.**

In the present case, this broader logic underpins the use of satellite-based monitoring within the Disaitek / So-B-Green / Africao chain. **The value lies not simply in observing plots from above, but in turning repeated observations into information that can support risk screening, compliance assessment, and more informed action across the supply chain.**

Continuity through time is also important because the relevant risk is not always confined to the plot itself: repeated observations can help identify broader deforestation pressure in the surrounding landscape, which may affect sourcing decisions and the assessment of future risk.

The operational value of continuous SAR monitoring therefore lies in its ability to turn raw pixel data into compliance-grade evidence usable in legal and commercial settings (the underlying physics of the technology is set out in the following chapter). When monitoring can reliably prove that there were no deforestation activities within a specific polygon and that it has been in agricultural use since at least 31 December 2020, operators can transition from generalised risk assessments to definitive compliance verification. This is operationally important because it allows screening to take place before resources are committed on the ground, helps organisations decide where to focus field validation activities and allows independent verification and external auditing. It also enables focused follow-up efforts rather than treating all sourcing areas with equal priority.

Within this framework, the Disaitek / So-B-Green / Africao case can be understood as a practical materialisation of the needs presented by the new paradigm in commodity trading: from trust-based sourcing to compliance verified by concrete data. **Disaitek frames its role precisely in these terms. Its proprietary data processing algorithms utilise Sentinel-1 time-series data to certify polygons in advance, offering "Stock Compliance" and "Shipment Compliance" tools**[24]. Comparable EO-based approaches in cocoa farming and forest management contexts show that the value of such services lies not only in detecting past change, but also in supporting structured risk profiling and more informed decision-making across sourcing areas. In practical terms, **the service functions as a decision-support tool through which compliance teams can screen farms, assess surrounding deforestation pressure, and connect geospatial checks to wider traceability and shipment workflows**.

The significance of the case therefore lies in the unique capabilities provided by Sentinel-1 data for developing tools and methodologies for efficient and reliable EUDR compliance. Through this, Sentinel data helps remove a major regulatory and operational bottleneck, allowing traders and compliance actors to make faster, better-informed decisions while supporting the continued integration of smallholder farmers into regulated international markets.

[24] Disaitek's "Stock Compliance" and "Shipment Compliance" modules map to the two principal operational compliance dimensions of the EUDR. Stock Compliance addresses the verification of historical land-cover for inventories against the 31 December 2020 cut-off date set by Article 3 of Regulation (EU) 2023/1115. Shipment Compliance addresses the obligation under Articles 4 and 8 to submit a Due Diligence Statement, containing the information set out in Annex II, before relevant products are placed on the EU market or exported.

3 The Use of Sentinel Data

3.1 How can satellites help with deforestation monitoring?

Remote sensing data and methodologies are considered one of the key tools used for provision of timely and accurate data used for forest monitoring and management. The combination of satellite imagery with meteorological data, biophysical modelling, and statistical analyses allows the continuous monitoring of forest ecosystems and the extraction of actionable information. This can allow for the detection and monitoring of forest ecosystem health and degradation, deforestation, phenological patterns and changes in land cover and land use related to food commodity supply 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.

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

Broadly speaking, there are two main classes of EO satellite systems (Figure 6):

- **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 (as it hinders solar radiation) and key data related to vegetation can only be observed 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 or insolation.

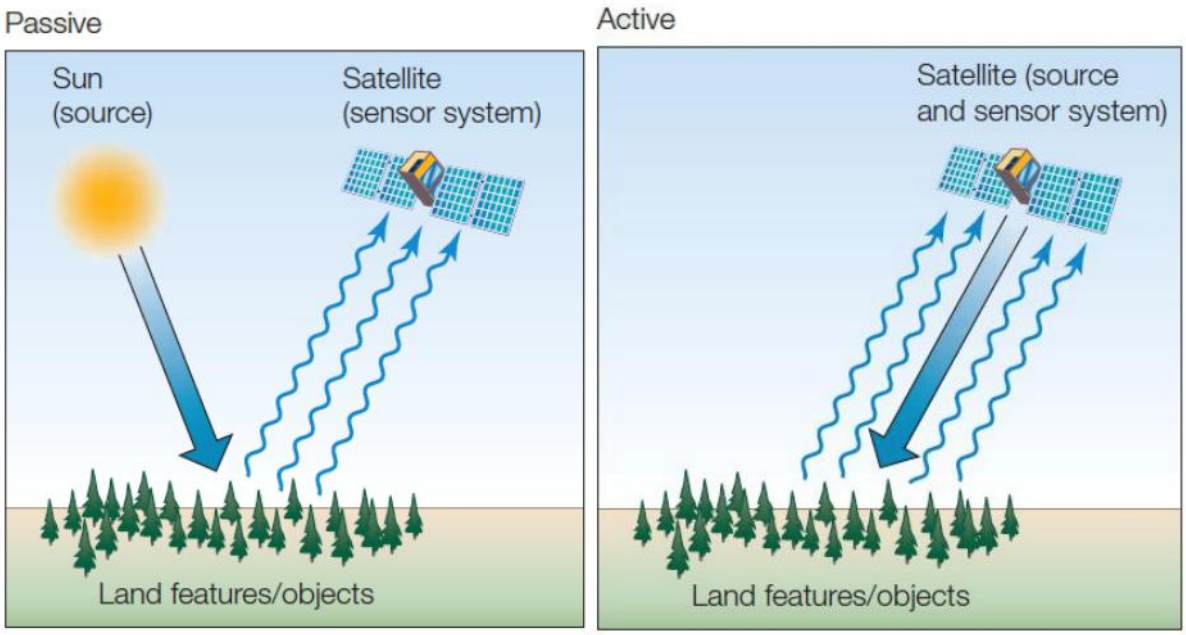

Figure 6 Passive (optical) versus active (radar) Earth observation (ESA EO Science for Society training materials, 2025)

Sentinel-1 is especially relevant in this context because it is a Synthetic Aperture Radar (SAR) mission operating in the C-band (Figure 7), and as other SAR EO systems, can provide systematic and repeatable observations independently of cloud cover and daylight.

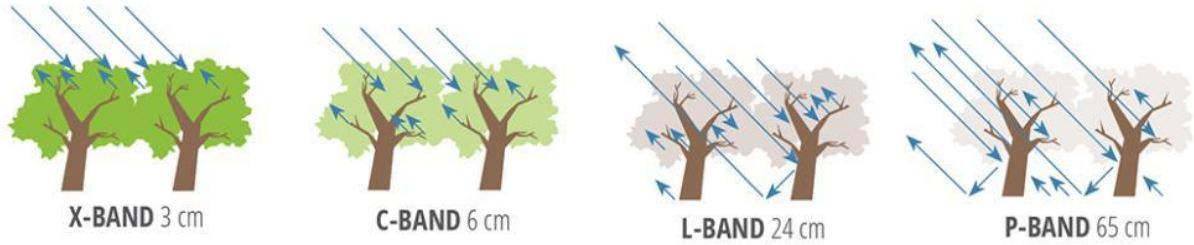

Figure 7 Sensitivity of SAR measurements to forest structure and penetration into the canopy at different wavelengths used for airborne or spaceborne remote sensing observations of the land surface. Credit: NASA SAR Handbook.

For monitoring applications in cloudy equatorial regions such as Ivory Coast, this consistency is particularly important and is one of the most valuable characteristics of the data, as it allows the creation of a much more reliable temporal record than can typically be achieved with optical imagery alone. Because radar backscatter is sensitive to the structural properties of the objects on Earth's surface, repeated SAR observations can also be used to detect structural changes in forest cover through time.

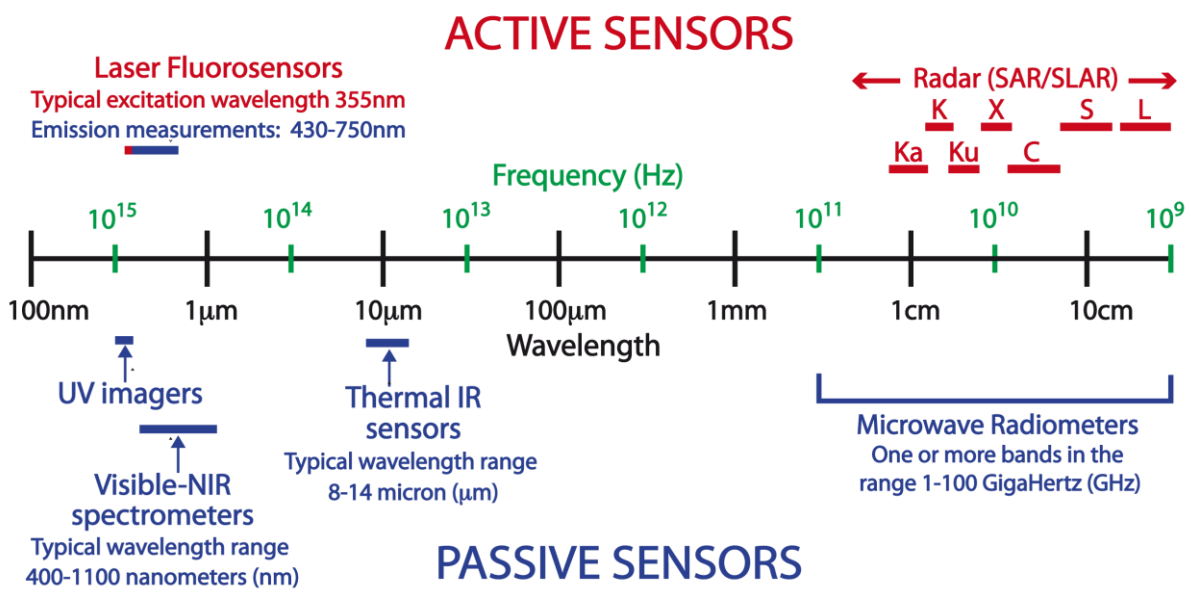

Figure 8 Schematic representation of the segments of the electro-magnetic spectrum in which each EO sensors operate

As seen in Figures 6 and 8, 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 EO satellites to distinguish between grasslands, water surfaces, forests, and buildings.

During the year, trees can shed or grow leaves and fruit depending on variables such as temperature, sunlight, and precipitation. Changes in the health, density, and vigour of trees affect the optical properties of the canopy, which can be measured using the various Vegetation Indices like the Normalised Difference Vegetation Index (NDVI) via optical satellites. However, land cover classification and structural changes can also be achieved using SAR satellites. Contrary to optical satellites – which essentially produce photographs – SAR imagery is a measure of how much energy is scattered back to the sensor after being reflected on different types of materials, providing an understanding on of the structure of the canopy and the tree trunks. Due to the properties of the EM energy in the microwave spectrum to penetrate different materials, with the penetration depth dependant on the band in which the system operates, SAR data can also provide structural understanding of the forest understory and vertical structure. This is particularly important for differentiating forest areas from cocoa plantations implementing shade trees and agroforestry principles. In operational settings such as this one, the value of this distinction is not merely technical. The use of radar makes it possible to generate more reliable information in tropical conditions where persistent cloud cover would otherwise undermine the continuity needed for compliance assessment and land-use history reconstruction and where forest structure is a key piece of information.

3.1.1 Advantages

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

- The capability to acquire data globally without any limitation by weather conditions (when using active SAR sensors). Satellites offer a robust source of near-real-time information to aid forest management.
- 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.
- Satellite images offer spatially continuous data coverage of an entire areas, with no further interpolation required, in contrast to ground-based discrete sampling.
- Finally, whilst EO satellite data are a complementary data source to in-situ data in most countries, they can be the only reliable source of information in countries lacking ground infrastructure or where field audits are economically unviable.
- User accessibility: when EO-derived outputs are translated into an operational platform, they can be used directly by non-specialist teams as a decision-support tool, without requiring advanced in-house expertise in satellite analysis.

3.1.2 Limitations

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

- **Resolution limitations:** Spatial resolution of commercial and open access satellite imagery may not be high enough to detect the required data at very small scales.
- **Cloud cover gaps:** For passive optical satellites, persistent cloud cover in equatorial regions creates massive gaps in historical data, creating an "optical trap" where compliance cannot be proven.
- **The Orbital Challenge (Active Sensors):** While radar penetrates clouds, monitoring equatorial regions presents a unique technical hurdle. Satellites do not always consistently provide both ascending and descending orbits over areas like Ivory Coast, requiring complex algorithmic workarounds to detect changes from a single viewing angle.
- **Procedural hurdles:** Forestry is a highly regulated industry segment, and this is true on the global level. Proscribed procedures and regulations need to be followed strictly, which is a hurdle in stronger uptake of satellite data in the sector.

Until a decade ago, another significant limitation was the cost of acquiring continuous time-series satellite data. That has progressively changed with the advent of the Sentinel

era – producing vast amounts of data under the Copernicus full, free, and open data policy.

Even so, turning raw EO data into decision-ready information still requires specialist interpretation, calibration, and service design, which means that the accessibility of the data alone does not remove the need for downstream expertise.

3.2 Copernicus and the Sentinels

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

Copernicus is an EU flagship programme. 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.

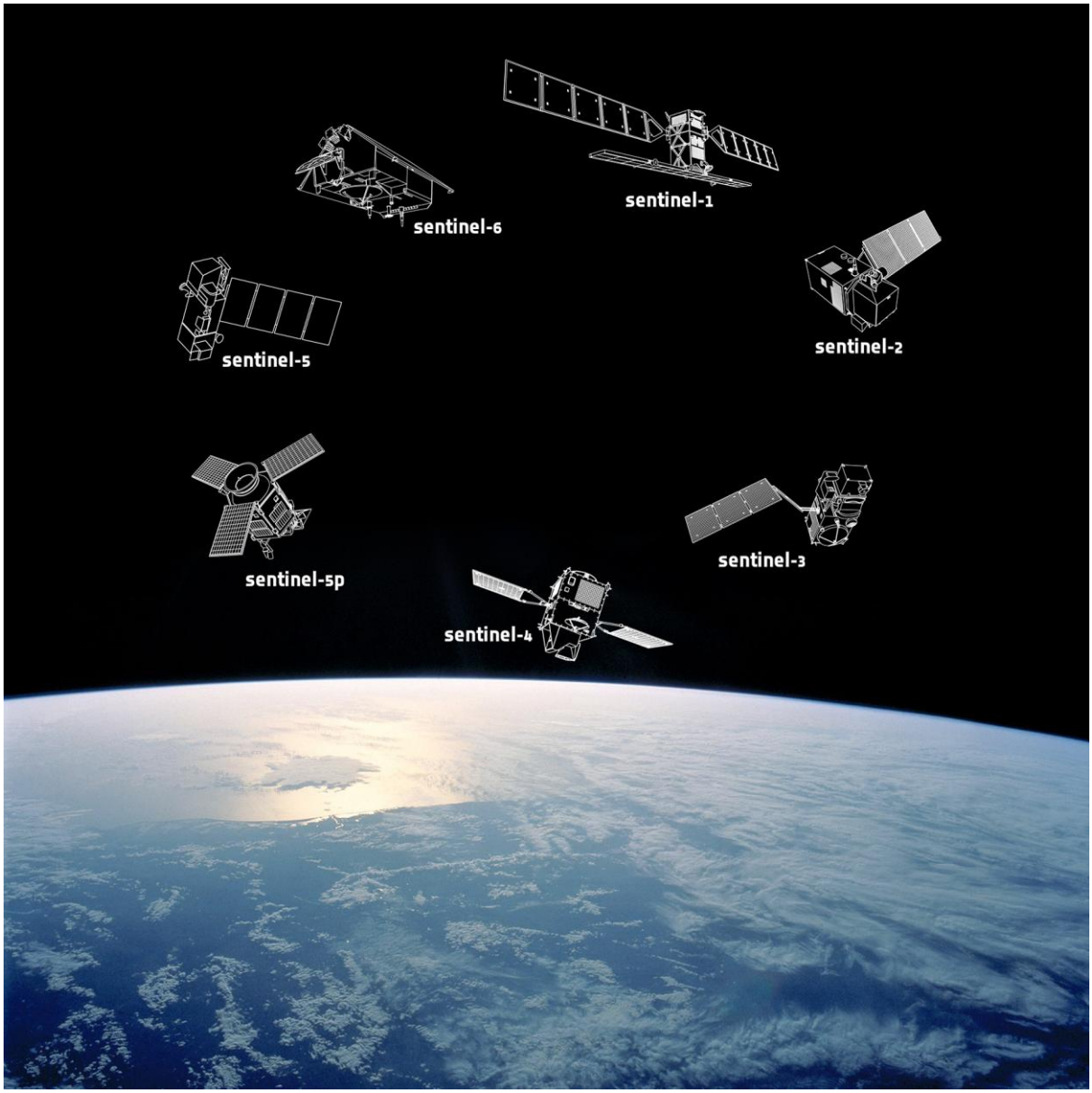

Figure 9 Current suite of Sentinel missions (ESA)

Sentinel-1 is a multi-satellite C-band Synthetic Aperture Radar (SAR) mission and is a part of a wider family of satellite missions (Figure 9) in the Copernicus programme dedicated to the observation of our planet. Originally designed as a twin-satellite system (Sentinel-1A and Sentinel-1B), the constellation now operates with three satellites (Sentinel-1A, Sentinel-1C and Sentinel-1D), following the loss of Sentinel-1B to an unrecoverable power-supply anomaly in December 2021 and the entry into service of Sentinel-1C in December 2024 and Sentinel-1D in November 2025. The mission provides 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 critical technique in monitoring forests in equatorial regions like Ivory Coast because its quality does not depend on weather conditions, cloud cover, or day/night light coverage.

In this case, the practical importance of the Copernicus model lies not only in data availability, but in the fact that the continuity and openness of Sentinel-1 make it feasible for downstream providers to build operational compliance services that can be used at scale by actors in the cocoa supply chain.

3.3 The Disaitek service

The Disaitek deforestation monitoring service is built on the utilisation of Sentinel-1 radar time series to overcome persistent cloud cover in West Africa and to detect structural changes in canopy cover. Disaitek's service is built to help importers ensure that no cocoa enters the European market if it originates from land deforested or degraded after 31 December 2020. The service heavily depends on the continuity of the Sentinel-1 archive. Since 2016, continuous acquisitions have made it possible to reconstruct land-cover history through time in a way that would be technically difficult and prohibitively expensive to achieve with commercial SAR data alone. In this sense, the Copernicus free and open data policy is fundamental, as it enables the historical depth needed to assess whether a detected change occurred before or after the EUDR cut-off date. Without Sentinel-1, there would be a major historical and operational blind spot, as no commercial alternative currently offers the same systematic and freely accessible C-band coverage at comparable scale.

The service did not emerge fully formed as a stand-alone compliance platform. Its development followed an iterative path in which earlier collaboration around agroforestry applications, including shade-tree identification, helped establish the working relationship with So-B-Green, and the calibration logic that later supported the EUDR-focused service.

Because optical-only approaches often fall into an "optical trap" in the tropics, where missing data leads to false compliance alerts, Disaitek uses the continuous Sentinel-1 C-band radar archive. By analysing scattering patterns, the system precisely detects physical structural changes in the forest structure, which definitively prove deforestation events. This preference for SAR data was also shaped by operational needs, but the reason runs deeper than cloud cover. Due to the properties of the rada signal, it can be considered more reliable than optical in the persistently cloudy tropical context, which matters for a service that has to support routine compliance use. The more important point concerns how each sensor establishes what the land cover was at the 31 December 2020 cut-off. Optical approaches typically infer that baseline through land cover classification, which returns a land cover label together with a confidence score. Such classifiers can misclassify agroforestry systems, where cocoa grows under shade trees, which to an optical system appear as closed forest. A plot labelled forest at the baseline can then appear to have been converted once cultivation is detected, exposing

a compliant smallholder to inappropriate exclusion. The radar-based approach developed by Disaitek is designed so that the final compliance assessment does not rest on this kind of probabilistic classification. It detects physical disturbance of the canopy directly, rather than inferring a land-cover class, which keeps the compliance verdict anchored to an observed change instead of to a model's confidence score.

To make this operational in West Africa, Disaitek had to overcome the specific "orbital challenge" of the region. Because Sentinel-1 does not consistently provide both ascending and descending orbits over Ivory Coast, Disaitek dedicated approximately 60% of its research and development (R&D) efforts to successfully build an algorithm capable of accurately detecting deforestation events using only descending or ascending orbital pattern of the satellites in the Sentinel-1 constellation.

A key feature of the service is that calibration does not rely on satellite analysis alone. The interpretation process is strengthened through iterative comparison with field observations, creating a feedback loop in which *in situ* verification is used to refine the outputs and improve their operational relevance. This methodology is consistent with the general principle of downstream EO service development, in which satellite-derived data is combined with socio-economic and ecological “ground truth” to generate more decision-relevant evidence. A similar logic is visible in general agriculture and forest management applications, where remote sensing data is combined with field-based evidence in order to support decision-support tools rather than standalone geospatial outputs.

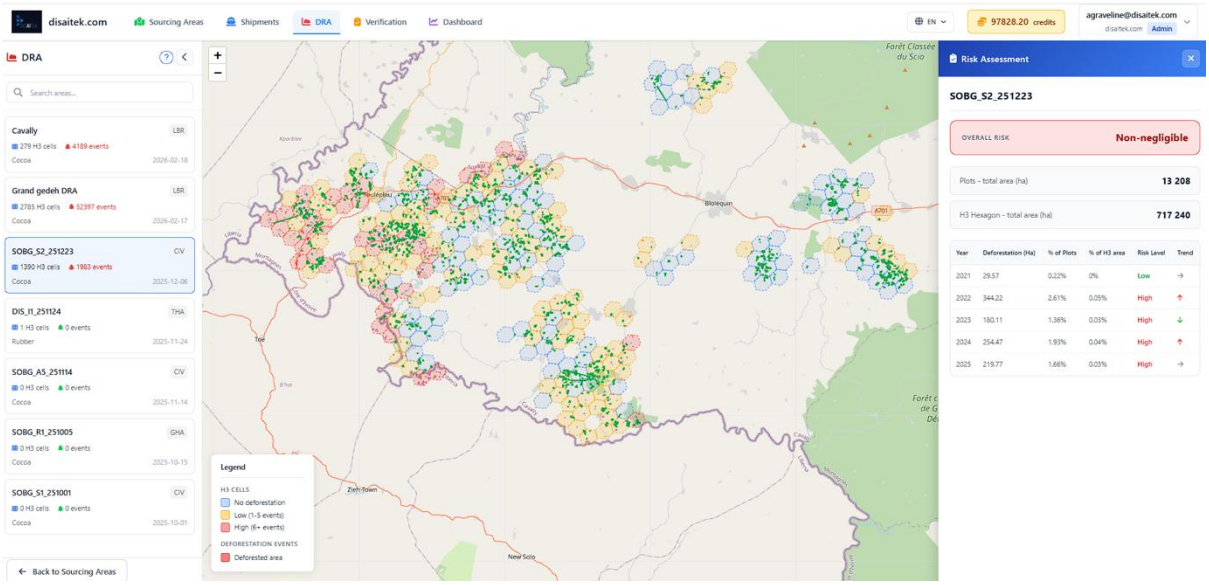

Figure 10 Disaitek’s deforestation monitoring service and compliance dashboard

The service creates EUDR compliance verification platform (Figure 10) which is integrated into the So-B-Green’s operational workflow, and which allows users to access and run analyses directly, rather than relying on manual back-and-forth reporting. This

shifts the model from receiving discrete validation reports from field teams to using a day-to-day tool integrated into the user's compliance workflow:

1. **Deforestation Risk Assessment & Satellite Checking:** Mapped supplier polygons are processed against 10 years of Sentinel-1 historical radar to assess the presence of deforestation prior to the EUDR cut-off date. In addition to checking historical compliance, the system analyses temporal patterns to help categorise sourcing areas into risk levels before any EU audit is requested. Comparable EO-based applications have also shown the usefulness of early area-level screening for deciding where deeper analysis and follow-up efforts should be concentrated. EO-based risk approaches in comparable contexts also show the value of combining multiple indicators such as historical deforestation patterns, agricultural conversion, cocoa presence, and ecosystem fragmentation to support more structured risk profiling. The service is used not only to assess the historical compliance status of individual farms, but also to evaluate deforestation pressure around sourcing areas, helping users identify landscapes where future risk may be rising even if a specific farm appears compliant at the time of assessment. These aspects of the service have been used to estimate the risk of entering new sourcing areas for existing and potential clients.

2. **Anti-Deforestation Laundering (ADL):** The algorithm assesses whether the geometry of the declared land plot is compatible with agricultural use, identifying fraudulent claims where a supplier might declare as sourcing plot different than the one used in reality, in order to avoid deforestation being detected on the relevant land parcel.

3. **Targeted Mitigation:** Through their partnership with So-B-Green, alerts generated by the satellite do not automatically ban farmers. Instead, they trigger a strict decision tree, deploying targeted field interventions, capacity building, and physical audits exactly where the satellite flags a risk. This is consistent with a wider logic in which EO-derived screening helps orient differentiated responses rather than uniform treatment, allowing mitigation and support actions to be tailored to the severity and type of risk identified. This logic is consistent with selective intervention approaches in which distinct ecological and socio-economic risk profiles are linked to different forms of restoration, governance support, awareness, or agricultural adaptation.

4. **Due Diligence Statement (DDS):** The final output combines field data with satellite proof to generate an EU audit-ready compliance report, including a Shipment Digital Passport and geospatial data exports, thereby providing verifiable evidence that can support due diligence submissions to EU authorities.

These outputs are designed to be used within the compliance and traceability workflow, so that geospatial verification can be linked to documentation, risk follow-up, and shipment-level decision-making rather than remaining a standalone technical result. In practice, this also supports the generation of the DDS-related workflow by linking shipment processing to the relevant European traceability infrastructure, making the service more directly usable in downstream compliance procedures (Figure 11).

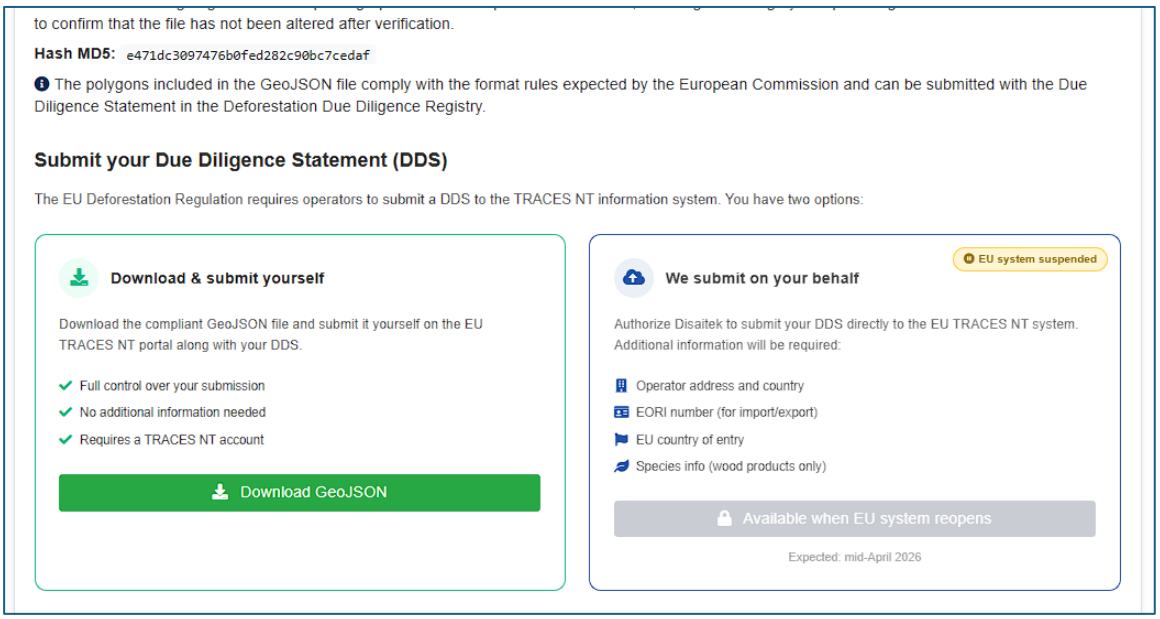

Figure 11 Due Diligence Statement submission options - Disaitek platform

By applying statistical rigour to downstream EO, Disaitek delivers time-stamped, polygon-level evidence of land-cover change with the temporal and spatial resolution and accuracy required for EUDR due diligence in a format that is strongly integrated into the operational procedures of the primary user.

A further characteristic of the service is that the platform is designed to remain usable for non-specialists. Teams can upload large numbers of polygons, trigger the analysis, and use the results directly for compliance or landscape-management purposes without requiring deep technical expertise in EO processing (Figure 12).

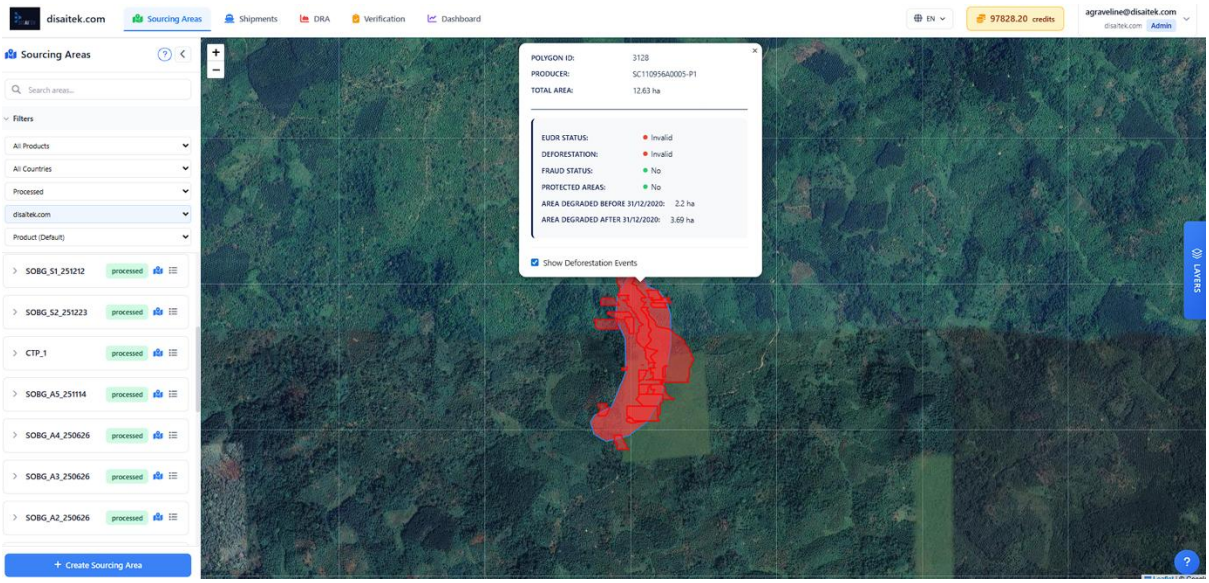

Figure 12 Single plot-level analytical interface of the Disaitek EUDR platform

3.3.1 Future evolution of the service

Following the successful deployment of their EUDR compliance service in Ivory Coast, Disaitek is expanding its monitoring capabilities across new geographies and technologies:

- **Geographic and Commodity Expansion:** The underlying monitoring logic is being scaled to monitor other EUDR-regulated commodities, such as rubber plantations in Thailand and cocoa in Ecuador and the Amazon basin.

- **Next-Generation Space Assets:** While Sentinel-1 provides the current historical backbone, Disaitek's technological roadmap includes pioneering multi-frequency SAR data fusion. They are actively preparing to integrate the ESA Biomass satellite (which utilises P-band radar). This integration will allow the service to simulate LiDAR responses, an advancement that will enable the assessment of the vertical structural complexity of forest ecosystems and maturity of agroforestry systems directly from space. This innovation trajectory is also reflected in related work in the cocoa sector, including exploratory activity on other EO-based monitoring applications beyond EUDR compliance.

4 Understanding the Value Chain

4.1 Description of value-chain

The core value chain in this case begins with the generation of satellite-derived compliance information and extends through its operational use, downstream commercial application, and wider societal effects. **At Tier 1, Disaitek processes Sentinel-1 radar data and transforms repeated observations into compliance-relevant outputs, including deforestation screening, land-use verification, and evidence that can support EUDR due diligence**. **At Tier 2, So-B-Green uses this information within a broader sustainability and compliance workflow**, combining satellite-derived outputs with traceability data, field verification, and mitigation actions in order to assess risk, support corrective action, and inform day-to-day operational decisions.

At Tier 3, Africao benefits from this Sentinel-enabled compliance process by gaining stronger evidence on the status of sourced cocoa and greater confidence in meeting EUDR requirements for access to the European market. This confidence is strengthened by the fact that plot-level analysis can be linked to shipment-level compliance procedures and wider traceability workflows, allowing the geospatial evidence to travel further down the value chain than a standalone map or technical report. In this way, the value of the satellite-derived information is translated from geospatial analysis into supply-chain decision-making, regulatory readiness, and commercial continuity. **At Tier 4, the benefits extend to citizens and society through the reduction of deforestation risk, the protection of environmentally sensitive areas, and the support of more sustainable smallholder integration into regulated international supply chains.**

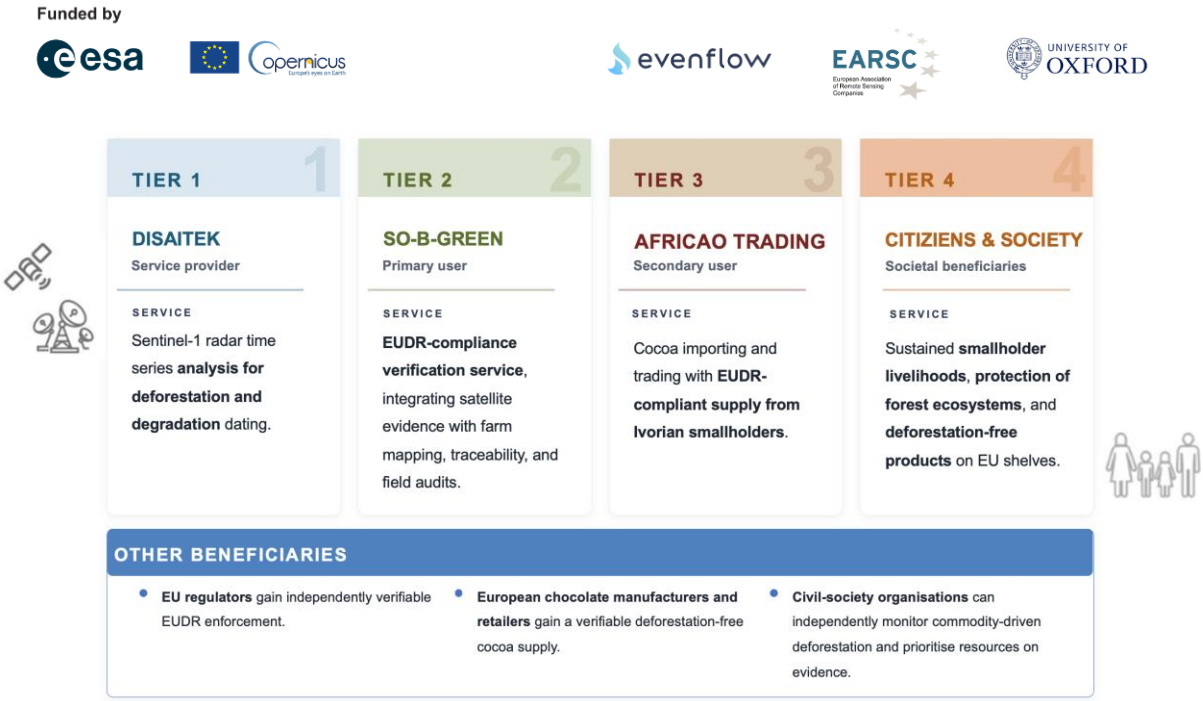

Figure 13 The value chain of the analysed EUDR compliance for cocoa sourcing in Ivory Coast

The value chain (Figure13) **therefore illustrates how freely available Sentinel-1 data can support a sequence of decisions and actions that begins with EO and extends to compliance processes, market access, environmental protection, and wider societal benefit**. The case is particularly relevant because the value of the data does not arise directly from the imagery itself, but from the way repeated radar observations are translated into usable compliance evidence and embedded in operational workflows across multiple actors.

4.2 Actors

4.2.1 The service provider (Tier 1) – Disaitek

Founded in Paris, France in 2017, **Disaitek** (Figure 14) **is an innovative technology company specialising in the intersection of Artificial Intelligence (AI) and EO**. Originally focused on space observation and deep-learning technologies for exoplanet identification, the company strategically pivoted in 2021 to address terrestrial environmental challenges, specifically biodiversity loss, climate change, and regulatory compliance. The credibility of this pivot was recently reinforced by Disaitek's inclusion in the French government's Greentech Innovation 2025 cohort. In the official list of labelled start-ups, the platform is described as aiming to combat agricultural deforestation and promote agroforestry practices favourable to parcel sustainability and carbon sequestration[25].

[25] French Ministry of Ecology (Ministère de la Transition écologique), 2025. "Greentech Innovation — Liste des startups labellisées" (List of labelled start-ups). Official catalogue of the Greentech Innovation 2025 cohort published by the French Ministry of Ecology, including the platform description of Disaitek as a company aiming to combat agricultural deforestation and promote agroforestry practices favourable to parcel sustainability and carbon sequestration. Available at: https://www.ecologie.gouv.fr/sites/default/files/documents/Greentech%20A4-liste.pdf

The technical credibility of this pivot is rooted in Disaitek's astrophysics DNA. Their approaches integrate the methodologies previously validated by NASA and ESA's PLATO mission. When transitioning to EO, Disaitek applied this statistical approach to regulatory compliance and forest monitoring. To sustain this level of innovation, **Disaitek maintains a highly specialised workforce consisting primarily of PhD-level experts in astrophysics, data science, and radar signal processing**. Approximately 80% of the company's person-days are dedicated purely to Research and Development (R&D). In addition to French national recognition, Disaitek also received peer recognition through the EARSC Product Awards at EXPANDEO 2024, where their platform for monitoring littering and illegal landfills received 2nd place in the Product Awards.

Figure 14 Disaitek's core team behind the EUDR service

In the context of the EU Deforestation Regulation, Disaitek focuses on deriving insight and providing actionable information to the rest of the value chain. Recognising the limitations of optical imagery in equatorial regions, **Disaitek built its EUDR compliance protocol heavily around Sentinel-1 radar data.** By leveraging the continuous, cloud-penetrating time series provided by this segment of the Copernicus programme since 2016, Disaitek's proprietary physics-based algorithms detect forest degradation or deforestation events on and around agricultural parcels. Disaitek delivers this capability through targeted service modules, such as "Stock Compliance," "Shipment Compliance," and continuous "Deforestation Risk Assessment." Crucially, they define a clear boundary in their value chain: they provide the automated, satellite-derived proof of compliance and risk alerts via secure applications. Although Disaitek acts as a scalable technology provider, and its satellite-based compliance layer can be deployed independently to generate risk alerts and documentary evidence, when the project context requires complex groundwork focused on interacting with cooperatives, conducting physical audits, and managing the social implementation of traceability falls to specialised **partners like So-B-Green, who bridge the gap between Disaitek's algorithms and the reality of the Ivorian cocoa fields**. The offering, implemented as a Software as a Service (SaaS) is designed to be accessed through an operational platform rather than only through bespoke reporting, which allows users to run analyses directly within their own workflows and increases the practical usability of the service downstream.

4.2.2 The primary user (Tier 2) – So-B-Green

If Disaitek provides the satellite evidence from space, So-B-Green provides the operational reality on the ground (Figure 15). Founded in 2018 as a "Social Business + Green" enterprise and active in West Africa since 2019 (Ghana from January, Liberia from May, Ivory Coast from October), So-B-Green is a sustainability consultancy with more than 70 field and office collaborators, specialising in structuring sustainable cocoa and coffee supply chains while delivering social, environmental, and economic value. Its Ivory Coast operations cover around 133,600 hectares within the Disaitek-monitored footprint, with 63,000 farmers enrolled in EUDR-compliance programmes and roughly 16,000 farmers actively coached. **The organisation acts as the bridge between satellite algorithms and the socio-economic reality of Ivorian cocoa cooperatives**, and its role demonstrates a principle that runs through this case: satellite data alone does not create compliance, it must be integrated into operational workflows.

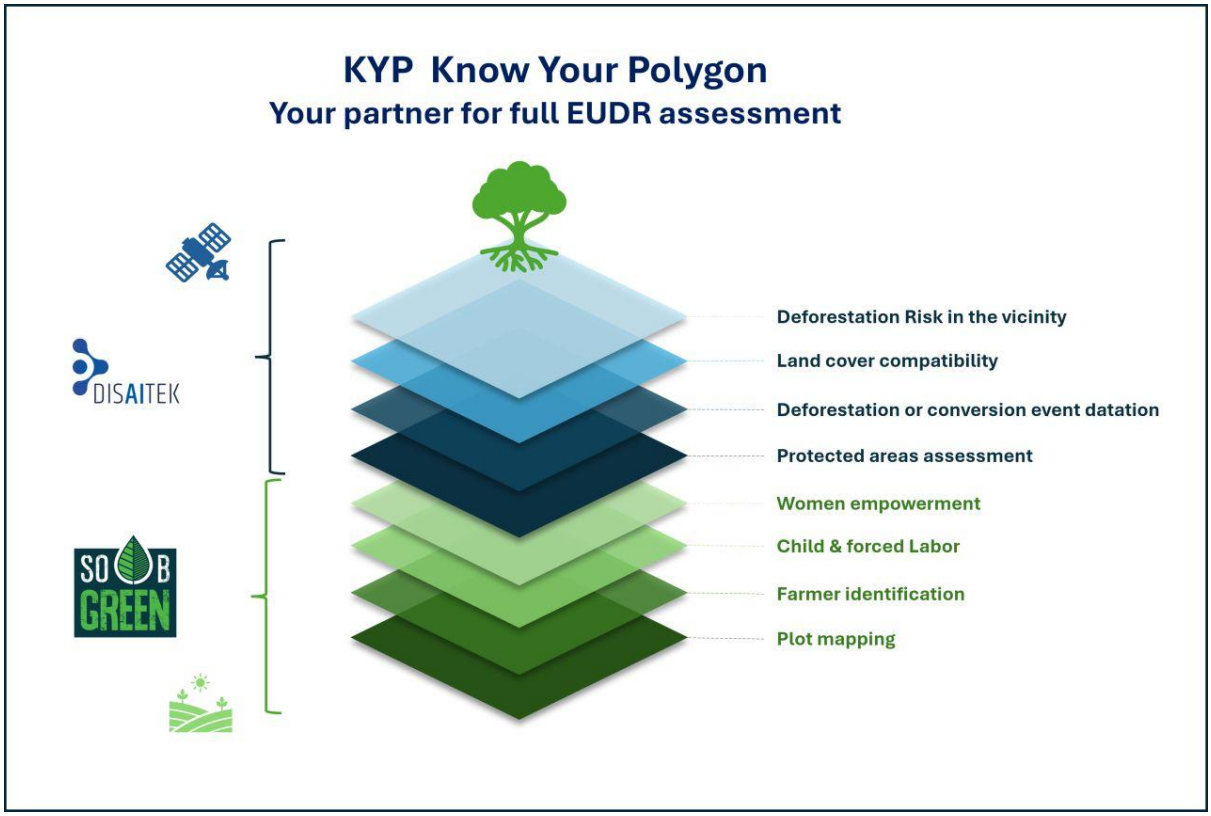

Figure 15 Illustrative architecture of the service offered by So-B-Green and Disaitek

So-B-Green organises its EUDR workflow as a 7-step process applied across the cocoa value chain (Figure 16). Steps 1 to 3 cover the foundational data layer: farm mapping, traceability system, and Internal Management System (IMS)[26]. Step 4 is the Geodata

[26] An Internal Management System (IMS) is commonly a centralised software platform for managing internal operations, compliance, and documentation. In this case the term is used more broadly, to designate the full set of procedures and tools for managing EUDR compliance.

Satellite Check, where Disaitek's analytics enter through polygon-level radar verification. Steps 5 to 7 handle the compliance and intervention layer: due diligence against EUDR readiness and country-risk standards, coaching and training with field intervention, and audit. Cooperatives at the upstream end of the chain pass through all seven steps; exporters, operators, and merchants further downstream engage with a subset of the steps relevant to their position.

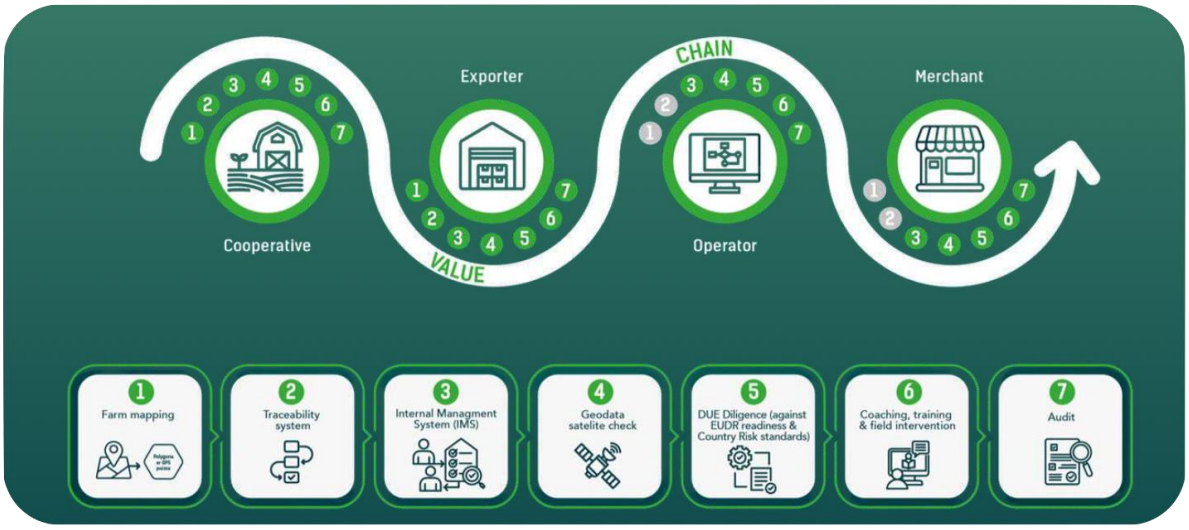

Figure 16 Illustration of the So-B-Green's 7-step EUDR operational workflow[27]

In Ivory Coast the field-and-logistics chain runs entirely on So-B-Green's own permanent-contract staff (Figure 17) and is So-B-Green financed end to end, anchored at village level by more than 44 active Local Environmental Committees that handle forest-risk governance. The operational model differs across countries: in Ghana, for example, client-side buying agents do the field work using So-B-Green designed questionnaires, with So-B-Green analysing the returned data and clearing or rejecting polygons remotely. The service has also evolved in its delivery model. What began as a more manual exchange of inputs and reports has become a platform-based mode of operation in which So-B-Green accesses Disaitek's system directly, uploads polygons, triggers analytical algorithms, and uses the outputs internally across compliance and landscape-management functions. **The EO-based functionality is now embedded in routine day-to-day work rather than remaining an occasional external input**.

So-B-Green's value-chain role therefore extends beyond translating Sentinel-1 insights into compliance outputs. Before the satellite check, the organisation manages farm mapping, traceability-system establishment, and Internal Management System (IMS) verification, all of which connect geospatial verification to the rest of the compliance chain. After the check, it handles downstream verification, decision-tree-driven risk profiling, and the targeted field actions that satellite flags trigger: capacity building,

[27] So-B-Green Company Profile presentation

support to cooperatives, agroforestry training, support for the Local Environmental Committees, and physical audits where they are needed. **The agroforestry programme had delivered around 15,000 hectares of cocoa-agroforestry by 2026, with approximately 60,000 shade trees planted in 2025 alone** and a per-cooperative survival rate of at least 50%. The same evidence base feeds adjacent data streams that So-B-Green handles, including traceability information, batch-level commodity flows, and socio-economic data, positioning the organisation as a decision-making infrastructure rather than an isolated geospatial product.

Figure 17 So-B-Green team planning a field visit to one of the cooperative's sourcing areas.

The clearest operational shift this arrangement enables is from field-based to exception-based auditing. **Before the satellite-enabled flagging system was in place, So-B-Green could not generate red flags at all because no such analysis existed**; the organisation handled illegal-logging events reactively through customary law and the chiefdoms when reports came through community channels. The Sentinel-enabled service does not replace that customary-governance layer; it adds a proactive layer on

top of it. In the counterfactual without satellite screening, validating thousands of smallholder polygons would require widespread deployment of field auditors, which is economically unviable at the per-tonne cost the cocoa market can carry and exposed to human error caused by bias or lack of expertise. By processing years of radar data automatically and quickly, Disaitek screens out polygons where no risk signal is detected. **This leaves So-B-Green to direct the bulk of its physical auditing and coaching budget to the smaller set of farms and sourcing areas** where satellite analysis indicates higher likelihood of compliance risk, with the field response itself calibrated to the type and severity of the flag rather than to a uniform protocol. The shift increases the efficiency of the validation process, reduces dependence on blanket field deployment, and matters particularly where risk is unevenly distributed across locations.

4.2.3 The secondary user (Tier 3) – Africao

Africao is a Geneva-headquartered commodity trader specialising in cocoa, coffee, and cashew nuts sourced from African origins (Figure 18). The company operates with a stated mission to facilitate trade of products sourced at origin into destination markets, notably European markets, framed in its own communications as "trade with impact." It sits outside the mandatory sustainability-reporting thresholds of the CSRD and of the Swiss Code of Obligations Articles 964a-c, but due to their nature of work they are directly engaged with the disclosure requirements of its EU customer base. The company sources cocoa from Côte d'Ivoire, its principal origin, at approximately 80-85%, alongside other West African and Latin American origins, and also trades Robusta coffee and a range of speciality products.

Figure 18 Africao Trader during the visit to Ivorian Cooperatives and Farmer Networks

At Tier 3, Africao is the European-market-facing operator that depends on the compliance ecosystem described in sections 4.2.1 and 4.2.2 for continued access to the EU market under EUDR. The company selected the So-B-Green / Disaitek partnership after evaluating alternatives, with the decisive factors being Disaitek's SAR based approach and So-B-Green's competitive service pricing.

The economic benefit at this tier is best understood not as incremental revenue but as what Africao has described as a "licence to operate": protected access to the EU market through audit-ready compliance evidence rather than through blanket precautionary supply retraction.

The strategic framing from Africao's side carries a distinctive angle. The company treats EUDR as a gateway to long-term opportunities beyond regulatory compliance, while

positioning the sustainability infrastructure built around the satellite layer as a long-term enabler of relationships with higher-tier customers, including Swiss chocolate makers and large multinational buyers. These organisations face multiple drivers for sustainable sourcing, as they benefit from the positive publicity, and are also subject to CSRD reporting and the overall ESG framework. Following this, the same infrastructure Africao is utilising for EUDR also supports the customer-driven evidence demand that already exists independent of EUDR. Africao expects the infrastructure to let it respond not only to large-customer requirements but also to propose field programmes back to those customers, drawing on its Africa-resident operational expertise. The company is in the materiality-assessment stage of its own first ESG report with So-B-Green, with the Disaitek satellite layer to be plugged into that narrative over the next one to two years. Other traders and importers traders in Africao's size band outsource their EUDR work to larger organisations within the sector, supplying only the polygons. Africao has taken the opposite approach: a dedicated sustainability team is already in place in its African operations, and the Geneva office is expected to expand with a full-time sustainability specialist. This reflects the company's deliberate strategy to position itself as a compliance leader among small-scale commodity traders.

4.2.4 Citizens and society (Tier 4)

Tier 4 is focused on the citizens and the society placed further downstream in the direct value chain, mainly the farmers and end consumers, as well as the communities adjacent to them. Benefits can of course be found for other beneficiaries of the case like EU regulators and the EU processing industry; however, these actors are recognised as beneficiaries that sit outside the value chain analysed in this study.

Ivorian smallholder cocoa farmers. Ivory Coast hosts approximately one million smallholder cocoa farmers, most of them working farms of a few hectares organised through cooperatives that connect them to the broader supply chain. Their relationship to EUDR is direct but mediated: Article 9 places the compliance obligation on Africao as the EU first-placer, but the practical effect flows back through So-B-Green and the cooperative structure to each individual plot, whose verifiable land-use history determines whether the cocoa from that farm continues to reach the EU market. **The Sentinel-anchored evidence allows individual smallholder plots to be sorted into compliant and non-compliant pools at the plot level rather than at the regional or supply-chain level**. The lived experience of this dynamic is captured in the words of a producer in Grand-Béréby, southwestern Côte d'Ivoire, whose farms are in the So-B-Green / Disaitek EUDR verification pool:

"When the EUDR project first started, I mainly saw the challenges: geolocation of plots, proof of no deforestation, and traceability. I was afraid of losing my plots. There were a lot of rumours circulating about the EUDR. I didn't understand how it would directly benefit my 5-hectare farm located in KAKO, in the Grand-Béréby area.

With technical support from So-B-Green, I received hands-on training in the field. The staff used GPS and a mobile app to map each of my three plots. I was given the exact area of 5.48 ha and proof that none of my plots are located in a restricted zone.

This process also allowed me to discover that 0.2 ha of my old plantations were located in a buffer zone adjacent to a protected forest.

So-B-Green advised me on compensatory reforestation and best agroforestry practices. Since then, I have stopped expanding my crops through deforestation and have planted 120 shade trees.

Today, the EUDR serves as a management tool for me: I know my production volumes by plot, I avoid child labour because I've formalized agreements with my workers, and I'm confident in the legality of my cocoa trees. This support has transformed the EUDR from an obligation into a tool for securing my farm and ensuring sustainable access to the European market. I recommend this approach to all producers in the cooperative."

The account captures the operational sequence the Sentinel-anchored chain enables at smallholder level: parcel-level geolocation, deforestation-status verification against the 31 December 2020 cut-off, discovery of partial buffer-zone exposure, restoration actions (120 shade trees planted), and the transformation of EUDR from existential threat into operational instrument for the farmer's own land-management decisions. This sequence captures the smallholder's structural position at **Tier 4: the individual plot is the unit at which EUDR compliance is decided, and the Sentinel-anchored evidence is the mechanism by which that decision is made.**

Communities adjacent to smallholder farms. The Tier 4 position reaches beyond individual farmers to the village-level communities in which they are embedded. So-B-Green's operational footprint already includes more than 44 active Local Environmental Committees that handle forest-risk governance at the village level. The systematic use of Sentinel-derived evidence to inform their discussions on land-use change, restoration priorities, and enforcement against illegal clearance is continuously being rolled out and is expected to come into full force by Q4 2026. The same applies to So-B-Green's agroforestry programmes, which have already delivered around 15,000 hectares of cocoa-agroforestry by 2026, with approximately 60,000 shade trees planted in 2025

alone, and which operate at the cooperative and village scale rather than at the individual farm level. These programmes exist independently of the satellite layer today, but the integration now underway is making the Sentinel-anchored evidence a routine input to their targeting, reach, and verifiability.

EU end consumers. End consumers of EU chocolate and confectionery products sit at the demand-side terminus of the cocoa value chain. Their structural position in Tier 4 is that of the largest single beneficiary group by population and the demand-side driver of the regulatory pressure that EUDR responds to. The detailed welfare argument and its Sentinel-attribution are developed in Section 5.2.4.

5 Assessing the Benefits

The benefit assessment follows a value-chain logic and examines how Sentinel data contribute to operational outputs, user actions, and resulting benefits across the different tiers of the case (Figure 19). **The analysis focuses on six benefit dimensions where relevant to the case: economic, environmental, societal, regulatory, innovation/entrepreneurship and science/technology related benefits**[28]. Not all dimensions are expected to be relevant or measurable in every case.

For each identified benefit, the assessment seeks to clarify five elements: (i) the stakeholder experiencing the benefit, (ii) the mechanism through which the benefit is created, (iii) the indicator or proxy used to assess it, (iv) the evidence on which the assessment is based, and (v) the extent to which the benefit can be attributed to the Sentinel-enabled service. Where sufficient evidence is available, models are developed and used to estimate indicative orders of magnitude. Where this is not possible, benefits are described qualitatively and linked to concrete operational effects.

Particular attention is given to attribution. The report does not assess the value of the overall service in generic terms but rather examines the extent to which Sentinel-derived inputs enable, improve, scale, or reduce the cost of the service compared with plausible alternatives or with a situation in which such information would not be available.

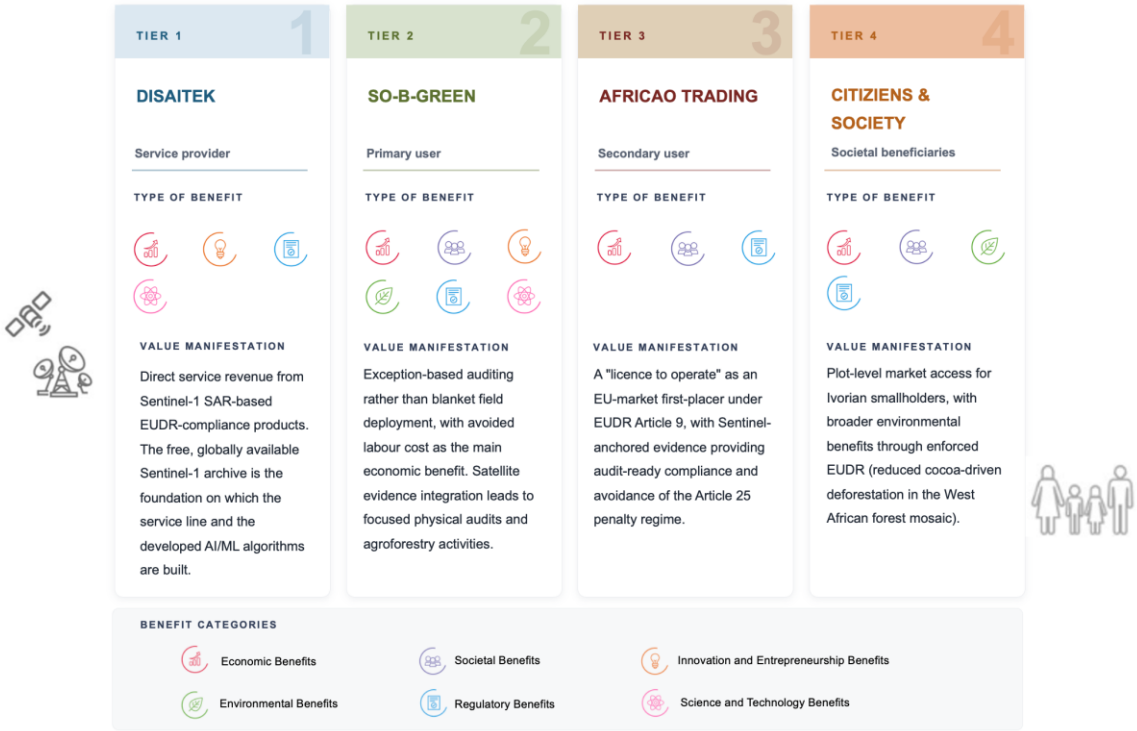

Figure 19 Benefits along the value chain

[28] Sawyer, G., Mamais, E. and Papadakis, D., 2022. "The Six Dimensions of Value Associated to the use of Copernicus Sentinel Data: Key Findings from the Sentinel Benefits Study." Frontiers in Environmental Science, 10, 804862.

5.1 Overview

This section assesses the benefits arising from Sentinel data across the EUDR compliance value chain for Ivory Coast cocoa. The value chain analysed has five tiers:

- Tier 1 - Disaitek (France): satellite-based EUDR compliance service provider. Develops and operates the Sentinel-1 algorithm stack for deforestation detection and at polygon level.
- Tier 2 - So-B-Green (France/Ivory Coast): field verification integrator. Combines Disaitek's satellite layer with on-ground field operations to deliver a full EUDR compliance package to cocoa importers.
- Tier 3 - Africao (Switzerland): cocoa importer focused on the EU market. Uses So-B-Green's service package to satisfy EUDR due diligence obligations and protects its EU market access.
- Tier 4 - Citizens, society and other beneficiaries: EU chocolate manufacturers and retailers (using Africao's compliance evidence to meet their own EUDR obligations and ESG commitments), EU regulatory authorities (relying on satellite-backed verification to operationalise enforcement at scale), civil society organisations (gaining transparency over corporate behaviour), and Ivorian smallholder farmers (benefiting from supply-chain access, from protection against arbitrary algorithmic exclusion, and from the agroforestry and resilience programmes the satellite-driven efficiency gains enable).

Three high-level observations frame the tier-by-tier analysis.

- ***Sentinel is the de facto operational backbone, not an optional enhancement.*** In each tier, the removal of Sentinel data does not degrade the service; it makes it collapse. Disaitek's founder states explicitly that without Sentinel-1's C-band SAR archive, the service would not have been built. So-B-Green's field verification model depends on Disaitek's flagging system to remain operationally and financially viable at scale. Africao's EUDR compliance status depends entirely on So-B-Green's satellite-backed due diligence output.

- ***The benefit cascade is sequential.*** Economic benefits do not arise independently at each tier, they flow from Tier 1 outward. Disaitek's algorithm enables So-B-Green's field targeting, which enables Africao's market access, which enables the downstream food industry to claim a deforestation-free supply chain. Attribution in every tier below Tier 1 is partly derivative; the Tier 1 benefit is not double-counted when the downstream tiers are quantified.

- ***The economic figures of 2025 are treated as the baseline for future projection.*** Full enforcement for large operators is scheduled for 30 December 2026. The benefit figures for 2025 reflect a compressed market in a launch year following two successive postponements. The ramp begins in earnest from 2026; full commercialisation is not expected before 2027-2028.

5.2 Benefits along the value chain

5.2.1 The service provider (Tier 1) – Disaitek

Economic Benefits

Disaitek (France) sells a polygon-level deforestation and land-use classification service. For each farm plot supplied by the client, they return: (i) whether the polygon is EUDR-compliant (no deforestation event after 31 December 2020); (ii) assessment of whether the plot is compatible with agricultural practices; (iii) deforestation pressure in the surrounding sourcing landscape. An automated sanity check on uploaded polygon geometry removes the need for manual quality control of thousands of GeoJSON entries. The deliverable is a SaaS platform accessed by the client's compliance team, with polygon and metadata maintained in Disaitek's database.

Why is Sentinel-1 essential for this operation? Three reasons, in priority order:

1. **Sentinel-1 C-band SAR archive back to 2017** needed because EUDR requires proof of no deforestation since 31 Dec 2020, which requires a time-series spanning *before* the cut-off. Sentinel-1 is the only sensor providing global 6-day revisit C-band SAR since 2017[29]. No commercial alternative exists at comparable cost, as confirmed by the Disaitek CEO.
2. **Cloud penetration in tropics and independence from probabilistic classification.** Ivory Coast, Ghana and the Republic of Congo lie under heavy, persistent cloud cover, so an optical-only service such as Sentinel-2 or Landsat misses deforestation events whenever cloud obscures the surface. The more fundamental issue, though, is not resolution but method: optical monitoring generally reconstructs the 2020 baseline through AI/ML land-cover classification, and such classifiers struggle to separate agroforestry from forest. Where shaded-cocoa agroforestry is misclassified as forest, a compliant plot can appear to have been converted once cultivation is detected, which is the methodological core of the EUDR problem in cocoa. Disaitek's approach based on Sentinel-1 detects physical canopy disturbance directly, so the compliance verdict does not depend on this classification step.
3. **Sentinel-2 as complement.** Used for post-disturbance land-transition classification (why deforestation happened) and regional land-cover mapping.

[29] The 6-day revisit applies to the two-satellite constellation. The Sentinel-1B anomaly on 23 December 2021 (mission formally ended 3 August 2022) extended revisit to 12 days under single-satellite operations until Sentinel-1C launched on 5 December 2024 restored the two-satellite cycle. Disaitek's usable archive from 2017 onwards reflects this evolving constellation status.

This is not crucial for the compliance/non-compliance verdict but supports the metadata layer.

Technical contribution Disaitek added on top of Sentinel: Sentinel-1 acquired from both ascending and descending orbits, but most of Ivory Coast, Ghana and northern Republic of Congo is covered by only one orbit direction. The standard deforestation-detection algorithms (developed by CESBIO/CNES under the TropiSCO[30] project, and related work by IGN) require both. Disaitek's R&D investment (~60% of total R&D time) went into reconstructing the missing viewing-angle signal, so the algorithm works in cocoa-growing West Africa. Sentinel data is the input; without it, the algorithm has nothing to reconstruct.

Benefit calculation – Adjusted Economic Benefit (AEB), 2025

At its core, this model seeks to isolate the financial value directly generated by an enabling asset, in this case, free Sentinel-1 data. Within the SeBS methodology, attributing value to open data typically requires the construction of a counterfactual by comparing the cost of using free Sentinel data with the cost of purchasing commercial equivalents. However, interviews with the company confirmed that no viable commercial alternative currently exists. Assessment against the 31 December 2020 cut-off depends on historical data with sufficient temporal depth and global coverage, and no commercial provider offers C-band radar historical archive that meets that requirement. Such an archive cannot be created after the fact. For this reason the standard fractional attribution approach was not appropriate in this case, and the benefit is attributed to Sentinel in full.

The economic benefit of the service was therefore assessed using an adjusted economic benefit model (AEB) based on company-provided information:

[30] TropiSCO is a tropical-deforestation monitoring platform developed by CNES and the CESBIO (Centre d'Études Spatiales de la BIOsphère) using Sentinel-1 radar time-series analysis, labelled by the Space Climate Observatory. The platform has been operational at tropisco.org since 27 June 2022, providing weekly deforestation maps for tropical regions, and the method detects deforested areas earlier than optical-only approaches in cloudy regions. Available at: https://www.spaceclimateobservatory.org/tropisco and https://tropisco.org/.

$$AEB = R - (C_{op} + C_{R\&D})$$

where:

AEB = Adjusted Economic Benefit

R = annual revenue generated by the 2025 EUDR service

C_{op} = direct operational delivery costs, including cloud, processing, and operational staff costs

$C_{R\&D}$ = annualised R&D-related costs allocated to the service

AEB = €39,000

In substantive terms, the model estimates the annual value retained by the service after subtracting the principal operational and development-related costs from annual revenue. It is therefore not intended to represent full company profit, but rather a simplified service-level estimate of the economic value made possible by Sentinel-1 data.

Using this approach, the AEB generated by Disaitek's 2025 EUDR service was estimated at approximately €39,000. In line with Disaitek's request, the key underlying business variables used to derive this figure are not disclosed individually in the report. Nevertheless, the estimate is based on company-provided information on service volume, pricing structure, operational costs, and allocated R&D-related costs, and was reviewed directly with the company to ensure that the final figure was methodologically consistent with the way the service operated in 2025. Disaitek also noted that, while the 2025 service operated under a polygon-based pricing logic, the commercial model was updated from 2026 onwards to better align with tonne-based customer expectations.

Based on the provided data from Disaitek, we were able to project the economic benefit in the five-year periods. Looking forward **2026-2030**, the pricing model shifts from per-polygon to per-tonne, so the projection runs on traded volume rather than polygon count. The conversion from monitored area to tonnes is based on the report of the World Cocoa Foundation on the average smallholder yield of 0.5 t/ha[31]. The actual pricing is business-sensitive data, hence, we only present in this report the set of our assumptions for the projection and its final outcome.

The projection covers Disaitek's full EUDR-related portfolio, which covered ~200,000 ha (~100,000 t-equivalent) in 2025 and grows as enforcement begins: the So-B-Green channel (133,600 ha) is the largest component, with further volume from Africao's phase 2, the Liberia and Thailand scale-up, the Ecuador cacao pipeline, and a broadening EUDR

[31] World Cocoa Foundation report on Ghana's cocoa production (2023). Available at: https://worldcocoafoundation.org/storage/files/cfi-ghana-annual-report-2023.pdf

operator base. Projected growth is driven primarily by expected increases in volume. The blended per-tonne price falls gradually over the period as volume discounts apply, while the cost base is assumed to remain relatively stable once the three-year R&D amortisation expires in 2027. **On these assumptions, AEB rises from ~€39,000 (2025) to roughly 6-8x that by 2030**. A simplified projection table is presented in Annex A1.1 to avoid revealing sensitive data from the service provider.

Regulatory Benefits

On the Regulatory side, EUDR is the demand-creating mechanism that the Disaitek service exists to serve, and the regulatory benefit at this tier runs bidirectionally. The regulation's structural requirements (polygon-level dated evidence of deforestation-free origin since 31 December 2020) directly shape Disaitek's product specification, with the three publicly named services (Stock Compliance for inventory verification, Shipment Compliance for per-batch DDS preparation, Deforestation Risk Assessment for surrounding-landscape monitoring). The forward commercial trajectory of the service is correspondingly tied to EUDR enforcement, with full enforcement for large operators scheduled for 30 December 2026. The same Sentinel-1-derived evidence chain is applicable across the wider EU and international regulatory stack, opening adjacent demand drivers: ESRS E4[32] biodiversity and ecosystems disclosure under CSRD[33], the TNFD[34] core global metrics, the value-chain due-diligence obligations of the CSDDD[35], and the EU Carbon Removal Certification Framework are all addressable regulatory areas. EUDR creates the market that Disaitek serves, and Disaitek's Sentinel-1 evidence in turn makes EUDR operationally feasible at scale.

[32] European Sustainability Reporting Standard E4 (ESRS E4 — Biodiversity and Ecosystems) is the topical biodiversity standard within the ESRS framework, adopted by the European Commission in Delegated Regulation (EU) 2023/2772 of 31 July 2023. ESRS E4 requires CSRD-reporting companies to disclose biodiversity- and ecosystem-related impacts, risks, opportunities, transition plans, and metrics, including land-use change and the proximity of operations to biodiversity-sensitive areas. Available at: https://eur-lex.europa.eu/eli/reg_del/2023/2772/oj

[33] The Corporate Sustainability Reporting Directive (CSRD), Directive (EU) 2022/2464 of 14 December 2022, is the EU framework requiring large and listed companies to report annually on environmental, social and governance performance using the European Sustainability Reporting Standards (ESRS). CSRD entered into force on 5 January 2023 and applies on a phased timeline. Available at: https://eur-lex.europa.eu/eli/dir/2022/2464/oj

[34] The Taskforce on Nature-related Financial Disclosures (TNFD) is a market-led, science-based global initiative that developed a voluntary disclosure framework for nature-related risks, dependencies, opportunities and impacts. The TNFD Recommendations, published in September 2023, include core global disclosure metrics covering land-use change, ecosystem condition, biodiversity, and freshwater use. Available at: https://tnfd.global/

[35] The Corporate Sustainability Due Diligence Directive (CSDDD), Directive (EU) 2024/1760 of 13 June 2024, is the EU framework requiring large companies to identify, prevent, mitigate and account for adverse human-rights and environmental impacts across their own operations and value chains, including mandatory supply-chain due diligence. CSDDD entered into force on 25 July 2024 and applies on a phased timeline. Available at: https://eur-lex.europa.eu/eli/dir/2024/1760/oj

Innovation and Entrepreneurship Benefits

On the Innovation side, **the Sentinel-1 radar archive is the foundation of Disaitek's current EUDR compliance offering**. The three publicly named services (Stock Compliance, Shipment Compliance, Deforestation Risk Assessment) all rely on Sentinel-1 as the primary detection layer. Recognition of this Sentinel-1 work specifically includes Disaitek's inclusion in the French government's Greentech Innovation 2025 cohort, where the company was labelled for its advanced radar technology supporting EUDR compliance.

A second-order benefit, contingent rather than direct, sits in the Disaitek-So-B-Green **R&D pipeline that was built around the Sentinel-1 service**. The pipeline is currently resulting in two joint developments: So-B-Carbon for farm-level carbon accounting, and the Cocoa Swollen Shoot Virus Disease early-detection concept based on hyperspectral satellite imagery (the latter positioned for future Copernicus missions such as CHIME, or for commercial hyperspectral providers, rather than current Sentinel-2 capabilities). Neither product relies directly on Sentinel data in its current form. They are attributable to Sentinel at the second order, through the partnership relationship that the Sentinel-EUDR work made possible, rather than through the satellite layer itself.

Science and Technology Benefits

The Science and Technology contribution is rooted in Disaitek's ability to combine advanced data science with Earth observation expertise. The company's scientific background includes earlier work on deep-learning methods applied to complex astrophysical signals, including contributions connected to NASA- and ESA-related research contexts. This experience has helped shape Disaitek's broader methodological culture: working with noisy, incomplete, time-dependent data and developing robust detection approaches where direct observation is constrained.

For EUDR-related deforestation monitoring, Disaitek applies this scientific and engineering expertise to Sentinel-1 radar time series. The approach is not a simple transfer of an astrophysics algorithm to Earth observation, but a domain-specific methodology design and adaptation for tropical forest monitoring, where cloud cover, smallholder landscapes, and temporal dating of land-cover change create specific technical challenges. At the algorithm layer, **the single-orbit SAR adaptation** that extends TropiSCO-style change detection into regions covered by only one Sentinel-1 viewing geometry, which is the product of approximately two-thirds of Disaitek's R&D effort, is transferable beyond West African cocoa. At the research level, the Massif de

Messok-Dja study[36] (Republic of Congo, November 2025) with So-B-Green and WWF Congo is the most developed published methodological output to date in this thematic area and is referenced here as methodological precedent for landscape-scale satellite-plus-field-survey work rather than as Ivorian evidence.

The strategic positioning of the Tier 1 service extends two vectors. First, the Sentinel-1-based capability is commodity-agnostic at the satellite layer: EUDR covers seven commodities (cattle, cocoa, coffee, oil palm, rubber, soy, wood), and the **same radar processing approach applies in principle across this commodity scope within tropical sourcing geographies**. Second, the capability is geography-agnostic at the satellite layer, with confirmed operations spanning Ivory Coast, Ghana, Liberia, and the Republic of Congo, and the forward projection assuming further expansion into South America, South-east Asia, and other tropical geographies through the 2028 to 2030 period.

5.2.2 Primary user (Tier 2) – So-B-Green

Economic Benefits

So-B-Green (France/Ivory Coast) delivers a full EUDR compliance package to cocoa importers by combining Disaitek's satellite layer with on-ground field operations. The workflow, integrated with Disaitek's platform since early 2026, operates in a phased process described in chapter 4.2.2.

In the **counterfactual where no Sentinel data exists**, the picture changes completely. Pre-2022 (before the pilot with Disaitek), So-B-Green's approach was reactive and governance-based: local governance committees with customary authorities and the Ministry of Forest and Water. These committees were a safeguard adopted in the absence of any precise monitoring tool: without one, the organisation had no way to tackle, at scale, what was happening on the ground. As So-B-Green put it, "there was no such tool, like a precise tool to have a scale of what was happening on the ground" (Interview with So-B-Green). EUDR requires per-polygon, per-shipment due diligence with deforestation evidence back to 2020, and to that effect this governance approach is insufficient. So-B-Green CEO's framing is direct: *"for EUDR, definitely having Disaitek with us, it's a must have now for us."* Without Disaitek (or an equivalent satellite layer), So-B-Green's only way to deliver EUDR-grade due diligence at scale would be to send field officers to every farm, not just the flagged ones.

[36] The Massif de Messok-Dja study is a 2025 collaborative output by Disaitek with So-B-Green and WWF Congo, conducted around the proposed Massif de Messok-Dja protected area in the Sangha region of the north of the Republic of Congo. The study combines Sentinel-anchored land-use and land-cover mapping with a 669-respondent community survey of Bakwélé villages around the Massif, integrating community territorial knowledge with satellite-derived land-use evidence to support landscape-scale conservation planning.

This dependency is what makes the **Avoided Labour Cost (ALC)** the right metric for So-B-Green's economic benefits. The satellite pre-screening layer eliminates the need to field-verify all but a small fraction of the polygon base. Remove it, and the field verification team must expand substantially to cover a much larger share of the portfolio manually. The ALC quantifies exactly that counterfactual staffing increase, the cost So-B-Green avoids by having Sentinel-enabled targeting.

Benefit calculation - Avoided Labour Cost (ALC)

Portfolio context and what it implies.

- Total managed area: **145,600 ha**; on-Disaitek: **133,600 ha** (~90%) - per interview with So-B-Green.
- Polygon base: ~2 ha/polygon (Disaitek processing convention) = **~66,800 polygons.** For simplicity, we assume that each polygon is a distinct farm plot that requires a compliance verdict under EUDR.
- Red-flag rates: Ghana 300/20,000 (1.5%); Ivory Coast 30/20,000 (0.15%); one client 8/8,000 (0.1%) as examples collected in the interview. These rates are the operational key: Sentinel-enabled screening routes only 0.1-1.5% of the polygon base to field officers. The remaining 98.5-99.9% are cleared remotely. Without Sentinel, that filter disappears, and the full polygon base must be resolved through other means.
- **Current Monitoring and evaluation (M&E) team: 5 officers. Average salary: €850/month = €10,200/year** (company-provided).

The 5 M&E officers are the dedicated staff whose workload is defined by deforestation monitoring, not So-B-Green's full Ivory Coast field team of ~58 (which handles a broader sustainability and sourcing mandate). Their specific remit is to receive flagged polygons from Disaitek, dispatch to farms, collect documentation, and report back. This is the team that scales if the satellite pre-screening layer disappears; the other field staff do not.

According to So-B-Green, without the Disaitek service, the company would need to 2-3x its M&E team to handle the EUDR compliance workload. We employ the 2x-3x multiplier as the headline figure but would like to note that it is an operational judgement rather than a mathematically derived one. In a strict no-Sentinel world, So-B-Green would need to build a compliance verdict on every polygon through manual processes. The raw workload increase is far larger than 2-3x: Sentinel currently flags ~0.15-1.5% of polygons (red-flag rates from portfolio context above: 0.15-1.50% across three clients), meaning the manual verification burden would be 67-667x higher in theory. So-B-Green's 2x-3x estimate is a practical operational judgement about the minimum team expansion

required to maintain a defensible (if not fully rigorous) compliance programme. This is an important distinction: the headline ALC is conservative precisely because it reflects what So-B-Green would actually do, not what EUDR would strictly demand. The upper-bound scenario below addresses the latter.

Table 1 Avoided labour cost (ALC) scenarios for So-B-Green

Counterfactual scenario	Additional officers required	Fully-loaded cost per officer	Gross avoided labour cost	less: Disaitek (assumed)	Net ALC (headline)
Double the M&E team (2x, So-B-Green's lower bound)	+5	€15,300	€76,500	-€47,000	€29,500
Triple the M&E team (3x, So-B-Green's upper bound)	+10	€15,300	€153,000	-€47,000	€106,000

The recommended headline range for net ALC is €29,500-€106,000/year, which applies two adjustments to the raw labour figure. First, the avoided officers are costed fully-loaded: the €10,200 salary plus a 1.5x overhead for travel, vehicles and supervision, giving €15,300 per officer. The 1.5x overhead is our assumption. Second, the figure subtracts what So-B-Green pays Disaitek for the satellite layer that makes the avoidance possible. Based on the total EUDR revenue of Disaitek and the share of So-B-Green monitored areas out of Disaitek's total monitored areas, we assumed the cost for EUDR that So-B-Green incurs from Disaitek is about €47,000/year[37]. The payment to Disaitek represents **Disaitek's revenue**, which is already captured at Tier 1. Therefore, subtracting it here keeps the cascade consistent rather than losing value.

The Disaitek-powered client base of So-B-Green extends well beyond Africao. Four new EUDR clients in the past year with an aggregating contract value of €320k-€1.4M/year. So-B-Green's CEO stated *"without Disaitek we won't have gotten the contract."* The geographic spread covers Ivory Coast, Ghana, Liberia, and the Republic of Congo, plus a South America prospect. EUDR broadly is ~40% of So-B-Green's revenue, and the 4 new EUDR clients alone account for ~40% of new revenue. When quantifying Tier 2 counterfactual benefit, the relevant volume is the full Disaitek-powered portfolio (133,600 ha), not just Africao's share.

[37] NOTE: The exact payment is governed by the commercial relationship between So-B-Green and Disaitek and is not disclosable. The 47,000 EUR/year figure is our estimate, derived from Disaitek's total EUDR revenue and So-B-Green's ~67% share of Disaitek's 2025 monitored area (about 66,800 polygons at the 2025 polygon price). It is used only as the amount netted out to avoid double-counting Disaitek's revenue.

Upper-bound scenario

The headline ALC (€29.5k-€106k) reflects So-B-Green's operational judgement: what So-B-Green would actually do in a no-Sentinel world. It does not reflect what EUDR legally requires, which is a per-polygon, per-shipment due diligence verdict backed by satellite evidence or equivalent documentation for every farm in the supply chain. Meeting this strict standard without Sentinel would require verifying a much larger share of the 66,800-polygon portfolio through manual means – a substantially more expensive scenario.

Two cost components combine in this scenario

- **Component 1 - Desk-based manual QA (calculable).** Without automated geometry checking and Sentinel-enabled deforestation flagging, every polygon must pass through manual Deforestation Risk Assessment (DRA) and Quality Assurance (QA) workflows. From Annex A-2: 8 staff-days per 1,000 polygons (DRA + QA). Total: 66,800 × 0.008 = 534 staff-days/yr. Daily rate: €850/month ÷ 18.33 working days/month = **€46.36/day**. Cost: 534 × €46.36 = **~€24,800/yr**. This is calculable because the workload is proportional to the polygon base and the rate is company-provided. It covers desk analysis only, no field visits.
- **Component 2 - Field verification (illustrative scenarios; no published standard prescribes a rate).** The per-farm field visit cost of €35 is anchored on So-B-Green's own operational data (Interview with So-B-Green; cited in Annex A at 10 farms × €35) with the assumption of 1 farm/polygon).

The key unknown is what share of the 66,800-polygon base would require a physical visit in a no-Sentinel scenario. No published standard prescribes a specific operator-level field verification rate for EUDR cocoa. The EUDR regulation (Article 9) requires "credible and verifiable evidence" of negligible deforestation risk per shipment but is technology-neutral and silent on sampling fractions. No cocoa-specific framework (Rainforest Alliance certification, IDH, ECA EUDR Protocol September 2025) sets a fixed field verification percentage.

What Article 9's burden-of-proof logic does establish is a directional pressure: without a credible remote sensing layer covering the full polygon base, a programme capable of withstanding regulatory scrutiny for each shipment would face an escalating field verification burden. The table below shows total cost at three illustrative coverage levels. These scenarios are not derived from any standard; they are presented solely to show the structural cost dynamics at different assumed verification shares.

Table 2: Hypothetical (upper-bound) cost saving for So-B-Green in different verification scenarios

Verification scenario	Polygons field-verified	Field cost (at €35/farm)	+ Desk QA (€/ year)	Total (€/ year)
25% (selective, risk-stratified programme)	€ 16,700	€ 584,500	€ 24,781	€ 609,281
50% (broad coverage)	€ 33,400	€ 1,169,000	€ 24,781	€ 1,193,781
100% (regulatory ceiling - full positive evidence per shipment)	€ 66,800	€ 2,338,000	€ 24,781	€ 2,362,781

This scenario is not reported as a headline figure for three reasons. First, the scenarios represent theoretical compliance positions, not what So-B-Green would actually implement. Second, all field verification shares are judgment-based, no published standard provides a specific rate for EUDR cocoa operators. Third, summing with the headline ALC would double-count the same labour. This scenario serves three functions: it demonstrates the regulatory exposure if the satellite layer is lost entirely; it confirms the headline ALC is conservative; and it shows why the market price (paid by Africao) for the full compliance package would be structurally impossible to sustain in a manual-only world at any substantial verification share.

Looking ahead across **2026-2030**, the net ALC scales with the M&E team, and the team grows with the portfolio. In 2025 and 2026 the team holds at **5 officers, giving a net ALC of €29.5k-€106k/yr**. From 2027, the first full enforcement year, the no-Sentinel team rises to **6 officers (€45k-€137k)**. It reaches 7 by 2028 as the portfolio expands roughly 30% and Africao's phase 2 begins (€60k-€167k), then settles at a steady state of 8 officers across **2029-2030 at ~200,000 ha (€75k-€198k)**. Each step applies the same 2x-3x counterfactual to a fully loaded, whole-headcount team (€15,300/officer/yr) and then nets the assumed €47,000/yr Disaitek payment, held flat. This is not a confident forecast; it depends on So-B-Green converting its pipeline. The full projection estimation can be found in Annex A1.3.

So-B-Green's integration of Disaitek's satellite layer into a full-service field operation model is itself a market innovation. It transforms a polygon-level remote sensing output into a compliance-ready package that smaller importers could not assemble independently.

Environmental Benefits

Impacts to state of nature can be examined from multiple angles or environmental attributes. To identify possible environmental dimensions from which to examine Sentinel benefits in SeBS360, we use the **Global Biodiversity Framework (GBF) to guide our analyses.** The GBF proposes 4 goals and 23 targets which are intended to capture a

wide array of actions that are needed to halt and reverse biodiversity loss by 2030 and beyond (CBD, 2022[38]), and paves the way for the collection of biodiversity-related data through a set of adopted indicators across a variety of themes, which includes metrics for monitoring protected areas, assessing the trends and status of species and ecosystem services, and monitoring sustainable resource use.

Environmental benefits via business operations route

From an operational perspective, we observe a more efficient resource use from the use of Sentinel data. As identified in the economic analysis section above, thanks to the analyses provided by Disaitek, So-B-Green can perform better-targeted monitoring operations to double-check the forest disturbance signals detected by Sentinel-1. This directly translates into a resource use reduction, for instance due to reduced field visits, leading to less fuel consumption, as well as reduced ecosystem disturbance

Environmental benefits via downstream impacts

Given the specific use of Sentinel-1 for deforestation mapping and promoting EUDR-certified cocoa production, this case study lends itself naturally to the examination of broader downstream biodiversity and ecosystem services benefits.

The environmental benefits analysis focused on characterising the biodiversity value of the landscapes in which So-B-Green operates, underscoring the importance of promoting conservation activities such as those required to meet EUDR certification (Figure 20 and 21). Concretely, we collected data on a set of biodiversity and environmental attributes that are likely impacted through the avoided deforestation and restoration activities undertaken by So-B-Green, which are uniquely enabled by the use of Sentinel-1 to map, and act upon, deforestation events. While our analysis does not follow a classical “impact evaluation” approach (i.e. through the use of statistical approaches to construct a counterfactual scenario) and cannot therefore be interpreted as a net Sentinel-attributable effect on the state of nature, it provides a picture of the biodiversity values that Sentinel data is helping to conserve, which is especially the case for farms that have achieved EUDR-compliant status.

[38] CBD. (2022). Decision adopted by the conference of the parties to the convention on biological diversity 15/4. Kunming-montreal global biodiversity framework. Available at: https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf

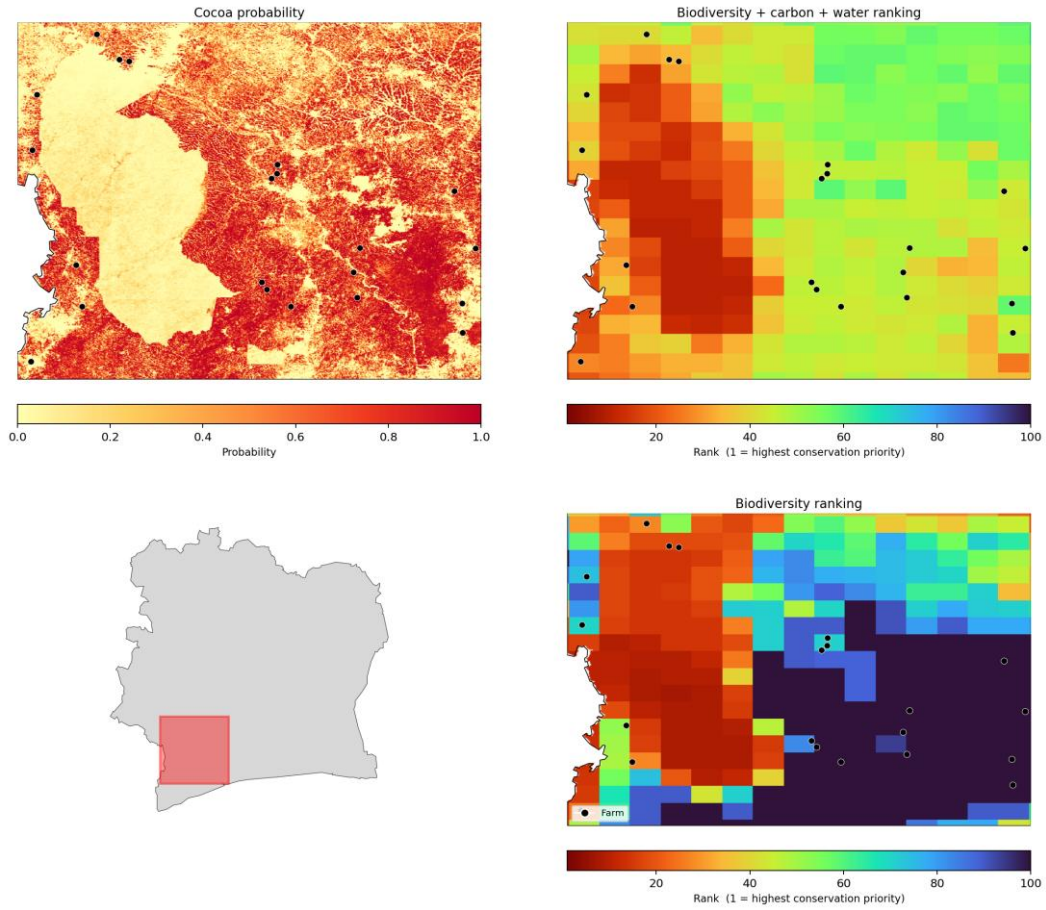

Figure 20 Spatial overview of So-B-Green farm locations in the southwestern Ivory Coast. (A) Cocoa probability layer (0–1). (B) Combined biodiversity, carbon, and water conservation priority ranking. (C) Study area extent (red) within Côte d'Ivoire. (D) Biodiversity-only conservation priority ranking (1–100). Black dots indicate a subset So-B-Green farm locations. The cluster of pixels highlighting areas of high conservation value correspond to the Complexe Parc national de Taï - Réserve naturelle partielle de faune du N'Zo.

Our assessment yielded insights into the importance of farm location data from a conservation perspective:

- Sampled farming areas covered by the So-B-Green's EUDR certification framework were located within 2 km of 27 reserves registered in the WDPA database[39], including Parc national de la Marahoué and Parc national de Taï, both assigned as strictly conserved protected areas (IUCN category II[40]) and the latter considered a UNESCO World Heritage Site due to its exceptional biodiversity and ecological value. Farms were additionally located next to the Complexe Parc national de Taï - Nzo Partial Fauna Reserve Complex, designated as a sustainable

[39] The World Database on Protected Areas (WDPA) **is** a comprehensive global database of marine, coastal, and terrestrial protected areas. It compiles spatial boundary polygons and descriptive attribute data, serving as a critical foundation for global conservation planning, ecological gap analysis, and policy decision-making. Source: https://www.protectedplanet.net/en/thematic-areas/wdpa?tab=WDPA

[40] IUCN Category II refers to National Parks, which are large natural or near-natural areas set aside to protect large-scale ecological processes and species

use protected area (IUCN category IV[41]), as well as in 24 additional reserves described under the Ivory Coast regulation as "Classified Forests", protected under national law, restricting land conversion and agricultural expansion.

- Examining the biodiversity intactness scores shows that the analysed samples of farms covered by the So-B-Green EUDR compliance workflow are located in areas important for biodiversity preservation, as shown by their Biodiversity Intactness Index (BII) scores and proximity to protected areas. BII scores in farm areas averaged 75.9% (74.5-76.8%) for vertebrates, 76.0% (74.4-76.9%) for plants only, and 76.2% (74.7-76.9%) across all taxa included in the BI - which aligns with the estimated mean BII value for sub-Saharan Africa of 76% (±14%).
- When analysing farms in terms of conservation ranking value - that is, the relative value assigned to these lands to help meet global biodiversity goals - the sample of So-B-Green farms is associated with a higher conservation value for biodiversity compared to the average cocoa farm in Ivory Coast. This is perhaps not surprising given that the sample we were given to analyse contains farm areas in proximity to highly valuable protected areas. Conserving forests adjacent to high conservation value areas allows to sustain biodiversity within managed but ecologically important habitats, while at the same time provides a buffer zone that shields protected areas from encroaching drivers of deforestation.

[41] IUCN Category IV is a protected area managed primarily for conservation through active, regular management intervention

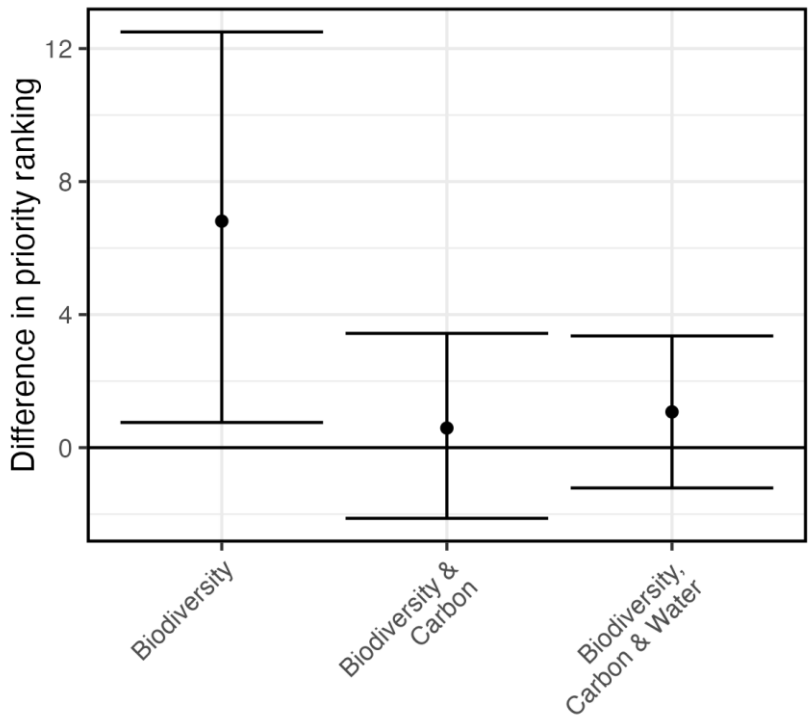

Figure 21 Conservation priority rankings, So-B-Green farms vs. average Ivor Coast. Higher values indicate higher conservation priority scores.

- We estimate an approximate biomass value of 72.3 [65.7–80.1] tons/ha in farm areas under So-B-Green operation. This equates to a total above-ground biomass of approximately 10.53 [9.57–11.66] million tons across the 145,600 ha managed area, underscoring the environmental significance of halting deforestation in these areas.

The environmental value is not limited to the assessed plots. **The same EO-derived information can also be used to identify broader deforestation pressure in surrounding landscapes, supporting more preventive action and wider sensitisation where risk is increasing**. This is important because the value of the service lies not only in determining whether a farm passes or fails a compliance check, but also in helping to differentiate what type of response may be most appropriate in a given context, whether this involves restoration, governance support, awareness-raising, or agricultural adaptation.

The benefits described above focus on the biodiversity value of the specific plots/parcels So-B-Green monitors. Utilisation of Sentinel-1 data also enables a set of further Tier 2 environmental benefits that extend beyond the parcel level.

Landscape-pressure analytics, derived from the same Sentinel-1 time series that supports per-polygon EUDR compliance, cover the area surrounding each parcel subject to verification. The reports identify where deforestation activity is rising regardless of whether that pressure currently sits inside a So-B-Green sourced farm. This gives So-B-Green, and through them the downstream operators, an **early-warning view of where to invest in pre-emptive interventions such as additional capacity-building with cooperatives, agroforestry expansion in buffer zones, or (where the risk is high enough) sourcing-area retraction or avoidance of doing business**. The information is **uniquely derived from Sentinel-1 data**, because no commercial alternative provides the combination of frequent revisit, cloud-penetrating coverage in the tropics, and global archive depth at the cost point that quarterly landscape-pressure reporting requires.

The proximity finding above translates into a concrete buffer-zone of potential environmental benefits. **The Sentinel-enabled monitoring of cocoa parcels adjacent to these areas effectively functions as an early-warning layer for the protected-area boundaries**. Deforestation pressure that builds at the cocoa-farming edge of a reserve is detected by the same satellite analysis that supports EUDR compliance, providing the evidence that protected-area managers and national authorities can act on before that pressure spills inside the reserve. This is the cleanest direct link between Tier 2 Sentinel data use and protected-area conservation outcomes in this case, opening the room for even greater utilisation for biodiversity conservation and habitat connectivity in the areas adjacent to protected land. The biomass figure of 72.3 [65.7-80.1] tonnes per hectare reported in the previous section is a point-in-time snapshot for 2022, derived from the ESA-CCI-AGB database (v6) which itself uses Sentinel-1 inputs. The same satellite archive enables tracking of biomass change over multi-year windows, which is the foundation for measuring restoration outcomes against So-B-Green's ongoing agroforestry programme (around 15,000 hectares of cocoa-agroforestry by 2026, approximately 60,000 shade trees planted in 2025 alone, with a per-cooperative survival rate of at least 50%). Future iterations of this assessment can move from a single-year snapshot to a trajectory analysis, opening the door to quantified avoided-loss and gained-biomass claims under the EU Carbon Removal Certification Framework or comparable carbon-disclosure regimes if the joint Disaitek / So-B-Green carbon-accounting work matures along that path.

So-B-Green supports more than 44 active Local Environmental Committees across its Ivorian footprint. The committees handle village-level governance of forest-risk decisions and increasingly draw on the Sentinel-derived flagging outputs as part of their evidence base. Before the satellite layer was introduced, village-level governance of forest-risk events relied on customary observation and on reports through conventional channels. Sentinel data layer adds an objective, dated, and spatially verifiable evidence stream that the committees can use in dialogue with local authorities, the Ministry of

Water and Forests, and the framework established under the Ivorian Code Forestier. The attribution here is again not direct but the link is clear: **the committees would exist without Sentinel data, but the precision and credibility of their decisions improve when satellite-derived evidence is available**.

Regulatory Benefits

So-B-Green operationalises the regulatory requirement compliance across the supply-chain interface. The Sentinel-1 evidence that Disaitek produces becomes usable for EUDR compliance only when it is integrated into the Due Diligence Statement preparation, Internal Management System (IMS) evidence chain and country-risk-standards assessment. Operators submit the DDS through the EUDR Information System on TRACES NT, which requires only the cleared, geolocated polygon files (GeoJSON) for the statement to be issued. The wider audit-ready compliance package that this evidence supports is not submitted to TRACES; it is retained by So-B-Green and Africao for at least five years and produced only if a competent authority opens an audit. The seven-step workflow is the structure through which this integration happens, with Disaitek's satellite check at Step 4 sitting between the upstream data-collection steps (farm mapping, traceability system, IMS) and the downstream compliance-and-intervention steps (Due Diligence against EUDR readiness and country-risk standards, coaching/training/field intervention, audit). The same Sentinel-anchored evidence base can also ease compliance beyond EUDR. Once generated for EUDR, it can be reused to support the biodiversity and ecosystems disclosures under ESRS E4 that clients with Corporate Sustainability Reporting Directive (CSRD) obligations have to produce, easing that process further down the value chain. The Sentinel layer is the enabling factor for all these pathways in their current form; So-B-Green provides the operational and reporting-architecture work that converts satellite data into regulatory-grade output.

Science and Technology Benefits

So-B-Green contributes to scientific knowledge production at three layers. At the research layer, the Massif de Messok-Dja study (Republic of Congo, November 2025) with Disaitek and WWF Congo combined Sentinel-1 deforestation monitoring with a 669-respondent Bakwélé socio-ecological field survey designed and run by So-B-Green. The integration of field survey procedures and satellite-based monitoring is a transferable methodological contribution for landscape-scale EUDR commodity related assessments, referenced here as Congo methodological precedent rather than as Ivorian evidence per the geographic-scope discipline. At the academic-partnership layer, So-B-Green's collaboration with the Institut National Polytechnique Houphouët-Boigny (INPHB) in Yamoussoukro is producing PhD-level plot-level carbon-stock and biodiversity measurements for Ivorian cocoa monoculture versus agroforestry; the work, once

published, will anchor the SEEA-EA[42] condition layer for the Ivorian footprint specifically. At the field-methodology layer, the operational integration of Disaitek's satellite analytics into a structured exception-based auditing pipeline at smallholder scale is itself a methodological contribution: the seven-step workflow demonstrates how Sentinel-derived flagging can be embedded within both compliance and restoration architecture that thousands of cocoa plots can pass through in a single analytical batch.

5.2.3 Tier 3 – Africao

Economic Benefits

Africao is a cocoa merchant/trader whose core business is the sourcing and marketing of cocoa from Côte d'Ivoire, representing approximately 80% of its revenues. The company is also expanding its procurement network across other West African producing countries and Latin America as part of a broader origin diversification strategy. As first-placer[43] under EUDR Article 9, full polygon-level due diligence applies to Africao regardless of the downstream simplification in the 2025 revision. In the economic analysis, we considered 2 assumed phases of Africao's EUDR-compliant cocoa volume namely Phase 1: 20,000-25,000 tonnes/year (current scenario) and Phase 2: 40,000+ tonnes/year (scale-up scenario for projection).

Africao does not interact with Disaitek directly in this particular case study (although relationship is direct in other instances). They contract So-B-Green for the full compliance package: polygon mapping of farmer plots, satellite verification (Disaitek under the hood), field confirmation of flagged farms, traceability data (via CCL/PCR Ltd), and an EUDR due diligence statement ready for the EU IT system. Africao's role: (i) finance the package (ii) integrate verified-compliant volume into EU sales contracts; (iii) build broader ESG programmes (Scope 3 carbon) around the EUDR baseline.

Africao's Sentinel-attributed benefit is a **cost-of-compliance benefit**. Without Sentinel, compliance would not become impossible, but it would become much harder to produce, so far fewer providers could deliver it. Demand, meanwhile, would not drop: producers still need EUDR-compliant due diligence to keep selling into the EU. A thin supply of capable providers facing that steady, inelastic demand can charge more, and Africao would pay the difference. Sentinel keeps the provider market wide enough that pricing stays competitive, and the money Africao does not have to pay is its cost-of-

[42] SEEA-EA stands for the System of Environmental-Economic Accounting — Ecosystem Accounting, the international statistical standard for measuring ecosystems and their contributions to the economy, adopted by the United Nations Statistical Commission at its 52nd session in March 2021. Available at: https://seea.un.org/ecosystem-accounting.

[43] Under the simplified EU Deforestation Regulation (EUDR) rules, the **"first placer"** is the business responsible for submitting the mandatory Due Diligence Statement (DDS) into the EU's central TRACES database.

compliance benefit. It adds to the Tier 1 and Tier 2 figures in the AEB total. The two-step calculation below quantifies this, with the scarcity scenario in step 2 sizing that price effect directly.

Cost-of-compliance benefit

This figure is built up in two steps. **Step 1** works out how much of So-B-Green's avoided labour cost (the Tier 2 figure) would reach Africao through the price it pays for the service. This gives a real number, but we do not count it here, because that saving has already been counted once at Tier 2. Adding Africao's share again would be the same value twice. In **Step 2**, we consider the scenario when there is no Sentinel. This would reduce the number of providers who could do the work, so the cost of compliance would not just rise in line with the extra labour, it would rise further because scarce providers can charge a premium. Africao would have to pay that premium on top. This extra amount is not part of the Tier 2 figure, so counting it does not double-count, and it is the number we consider as the Tier 3 cost-of-compliance benefit. In step 2, the premium is calculated as a multiple of the pass-through base found in step 1.

Step 1 – Attribute So-B-Green's avoided labour to Africao's share

Considering Africao's EUDR-compliant phase 1 mid-point 22,500 t/yr and based on the World Cocoa Foundation, smallholders yield around 0.5 t/ha, which comes from roughly 45,000 ha of farmland that Africao buys from. So-B-Green's Sentinel-backed portfolio covers 133,600 ha meaning that Africao accounts for about 34% of the portfolio area (45,000 / 133,600). Applying this 34% share to So-B-Green's avoided labour cost of €29.5k-€106k/yr (the Tier 2 ALC) puts roughly **€10k-€36k/yr** of avoided labour cost to Africao's volume.

Step 2 – The scarcity premium

Step 1 assumes that, without Sentinel, compliance would simply need more labour at the same competitive price. However, this assumption cannot be sustained in a free market economy. Removing Sentinel shrinks the set of providers able to meet EUDR's per-polygon evidence requirement. Demand stays fixed, since compliance is mandatory, while the supply of capable providers is limited. The price Africao pays therefore rises by more than the underlying labour cost. That extra gap is the scarcity premium: the part of the bill that Sentinel keeps off the table by holding the provider market open and competitive. The Tier 2 ALC cannot see this gap, because it measures only So-B-Green's own labour, not what the wider market would charge. The premium does not overlap Tier 2, and it is the figure we count toward the AEB.

We express the total no-Sentinel cost increase as a multiplier on the step-1 base of €10k-€36k. The regulatory cost pass-through literature finds total amplification of about 1.5x to 2.3x direct compliance cost under normal competitive conditions (Ackerman and Massey, *The True Costs of REACH*)[44]. The mechanism here, mandatory demand meeting a technology bottleneck, sits at or above the upper end of that range, so we use a 1.5x to 2.5x band with 2.0x as the central case. The multiplier separates into two parts. The first 1.0x is the pure labour pass-through from step 1, which is already counted at Tier 2 and is left out here. Everything above 1.0x, calculated as (multiplier - 1) x base, is the scarcity saving, and that is the part we count.

Table 3: Cost saving for Africao considering scarcity premium in different multiplier scenarios

Multiplier	Total Africao cost increase	of which: step-1 pass-through (not counted)	Scarcity premium (counted)	Interpretation
1.0x	€9,936-€35,704	€9,936-€35,704	€0	No market effect; pure pass-through (floor)
1.5x	€14,904-€53,555	€9,936-€35,704	€4,968-€17,852	Moderate scarcity premium
2.0x (central)	€19,872-€71,407	€9,936-€35,704	€9,936-€35,704	Mandatory + bottleneck typical
2.5x	€24,841-€89,259	€9,936-€35,704	€14,905-€53,555	Strong scarcity premium

Cost-of-compliance benefit counted in the AEB: ~€10k-€36k/yr (2.0x central). This is the scarcity premium only, the price increase Africao avoids beyond the labour saving already counted at Tier 2. At the 2.0x central case it happens to equal the step-1 pass-through numerically, but it is a different quantity: step 1 is a slice of So-B-Green's saving (overlaps Tier 2), the premium is Africao's own market-scarcity exposure (no overlap). Only the premium enters the AEB sum.

A limitation is that part of the scarcity premium can be a transfer from Africao to providers (economic rent), not a pure resource saving destroyed. SeBS uses a benefit-to-the-beneficiary framing, so counting it as Africao's avoided cost is acceptable, provided the providers' offsetting gain is not also counted elsewhere, which it is not in this analysis.

Looking ahead across 2026-2030, the Tier 3 figure counted in the AEB is the scarcity premium (step 2), which scales with Africao's volume. The step-1 pass-through is shown

[44] Nordic Council of Ministers, 2004. "The True Costs of REACH", by Ackerman, F. and Massey, R. (Global Development and Environment Institute, Tufts University). TemaNord 2004:557, a study examining the economic costs of the EU's Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation, with implications for regulatory cost-benefit framing in chemicals legislation. Available at: https://www.bu.edu/eci/files/2019/06/TrueCostsREACH.pdf

alongside it for transparency but is not summed, it is the part that overlaps Tier 2. When Africao's volume scales to phase 2 (40k+ tonnes), their share of So-B-Green's portfolio rises; at 40,000 tonnes and ~50% share the counted premium rises to roughly €18k-€63k/yr.

Table 4: Projection of cost saving for Africao considering scarcity premium (central multiplier)

Year	Africao volume (t, est.)	Scarcity premium counted (2.0x) - Low	Scarcity premium counted (2.0x) - High	Key driver
2025 (actual)	22,500	9,936	35,704	Phase 1; ~34% of So-B-Green portfolio (~45k ha)
2026	22,500	9,936	35,704	Stable volume; enforcement starts December 2026
2027	25,000	11,040	39,671	December 2026 enforcement in force; partial phase 2 starts
2028	30,000	13,249	47,605	Phase 2 ramp; portfolio share ~40%
2029	35,000	15,457	55,539	Continued phase 2; International expansion
2030	40,000	17,665	63,473	Phase 2 full scale; volume scaled linearly from 2025 base

Step-1 pass-through: Africao volume scaled proportionally from the 2025 base (22,500 t → portfolio share × Tier 2 ALC). Counted premium = (2.0 - 1) × step-1 base = the scarcity component only (numerically equal to the step-1 figure at the 2.0x central case, but conceptually the non-overlapping part; see step 2 above). The pass-through column is not summed into the AEB because it duplicates value already counted at Tier 2.

Regulatory Benefits

At the heart of Africao's regulatory position is its EUDR Article 9 first-placer obligation. As the operator placing cocoa on the EU market, Africao is required to submit a Due Diligence Statement for every shipment, demonstrating that the cocoa originates from land not deforested or degraded after 31 December 2020 and complies with the legislation of the producing country. The Sentinel-anchored verifiability evidence supplied through So-B-Green is the essential input that lets Africao meet this obligation at scale, preserving the EU-market access on which the trader's business model depends and avoiding the Article 25 penalty regime (fines of at least four per cent of EU

turnover, product confiscation, and exclusion from public procurement). In direct terms, the regulatory benefit at Tier 3 is the entire commercial proposition: without the Sentinel layer, Africao would not be able to place cocoa on the EU market at the Phase 1 scale it operates, let alone the Phase 2 expansion it has planned. As framed by the leadership of Africao, this can be considered as their licence to operate.

Beyond the first-placer obligation, the same Sentinel-anchored evidence flows further along Africao's value chain into the regulatory disclosures of its EU customers, who face direct obligations under ESRS E4 biodiversity reporting under CSRD, the TNFD core global metrics, the CSDDD due-diligence obligations, and the EU Carbon Removals and Carbon Farming Certification Framework, for which Africao itself is not currently required to file. Africao therefore has the potential to become a preferred supplier because the verifiability evidence it provides reduces its EU customers' own compliance burden across the sustainability stack of large-scale EU-based clients. The same evidence also positions Africao for an industry-wide shift from traceability toward verifiability that began before EUDR and would continue independent of it. The Sentinel-1 layer underpins all of these pathways, from the operator's own compliance through to the buyer-side regulatory leverage.

Societal Benefits

Two partially Sentinel-attributable channels operate at Tier 3. Africao's compliance investment maintains EU-market access for the Ivorian smallholders that supply its Phase 1 volumes, supporting smallholder livelihoods through continued buyer relationships rather than exposing them to the precautionary supply-retraction that uncompliant supply chains would face. Separately, the credibility of Africao's Sentinel-anchored sustainability infrastructure opens access to higher-tier customer relationships (Swiss chocolate makers and large multinational buyers), through which Africao can later propose field programmes back to those customers drawing on its regional expertise in Africa. The trader-and-smallholder relationships exist independently of the satellite layer, but the compliance processes that frame those relationships depend on it.

5.2.4 Tier 4 – Citizens and society

The analysis of benefits in Tier 4 is focused on the citizens and the society placed further downstream in the direct value chain, mainly the farmers and end consumers, as well as the communities adjacent to them. Benefits can of course be found for other beneficiaries of the case like EU regulators and the processing industry. These aspects will be covered in more detail in the following section

Economic Benefits

The direct economic benefit at Tier 4 is the improvement in market conditions experienced by compliant Ivorian cocoa smallholders and cooperatives. EUDR enforcement reduces the effective EU-bound supply pool by excluding cocoa from cooperatives that cannot demonstrate compliance, which raises the implicit market value of supply that can. Compliant smallholders therefore benefit from stronger buyer competition, more stable contract terms, and access to higher-tier buyer relationships that were not previously open to them. The Sentinel-anchored evidence chain operated through Disaitek and So-B-Green is the mechanism by which an individual smallholder plot is brought into the compliant pool, since field-only verification is not economically viable at smallholder scale and self-certification carries no legal weight under EUDR. The scarcity-premium dynamic analysed at Tier 3 creates room for a portion of the compliance-driven margin to flow back to compliant cooperatives through contract terms, supplier-development programmes, and beyond-compliance overlays such as agroforestry premiums, although the actual flow depends on cooperative bargaining position rather than being automatic.

This benefit is distributionally selective. Non-compliant smallholders and cooperatives face the inverse: market exclusion from EU buyers (Moluh Njoya et. Al, 2025), with the compliance-driven margin captured by their compliant peers[45]. The Tier 4 economic benefit therefore accrues to the compliant pool rather than to Ivorian smallholders in aggregate, and the Sentinel-anchored verification mechanism is what determines the boundary between the two.

Environmental Benefits

The direct Sentinel-attributable environmental benefit at the citizen and society level is the avoided deforestation that follows from EUDR's enforcement architecture being operationally feasible at smallholder scale. EUDR compliance verification methodologies which are either not economically viable or not data-feasible at the parcel-level cadence EUDR requires across fragmented smallholder landscapes would push the compliance cost heavily on the farming community. Additionally, without an economically viable enforcement layer, EUDR could tend toward precautionary blanket measures that either over-exclude (penalising compliant farmers) or under-enforce (allowing non-compliant supply to continue feeding the EU market). Selective enforcement is what creates the real economic disincentive against forest clearance for

[45] Zhunusova, Eliza & Ahimbisibwe, Vianny & Le, Sen & Sadeghi, Azin & Toledo-Aceves, Tarin & Kabwe, Gillian & Günter, Sven. (2022). Potential impacts of the proposed EU regulation on deforestation-free supply chains on smallholders, indigenous peoples, and local communities in producer countries outside the EU. Forest Policy and Economics. 143. 102817. 10.1016/j.forpol.2022.102817.

cocoa expansion, and the downstream environmental effects follow directly from this avoided-deforestation channel: preserved primary and secondary forest cover across the Ivorian cocoa belt, preserved above-ground carbon stocks, reduced pressure on protected areas such as the Taï National Park and the Cavally Forest Reserve, and preserved habitat for forest-dependent species across the West African forest mosaic.

Viewed from a global perspective, part of the environmental benefit sits on top of EUDR rather than within it, produced in synergy with Sentinel-1 enabled verification rather than by the regulation alone. Without an affordable or feasible verification layer, weak or blanket enforcement would tend to displace forest conversion rather than prevent it. Non-compliant supply would simply be rerouted to less demanding markets, and the deforestation would continue for another buyer[46] (Boysen, 2025). By making compliant status verifiable at the parcel level, and by keeping non-compliant plots visible rather than letting them slip unchecked into other supply chains, the Sentinel enabled methodology turns what would otherwise be displaced deforestation into avoided deforestation. This is an environmental gain for society that is attributable to the satellite evidence rather than to the regulation itself.

Regulatory Benefits

The most immediate regulatory benefit at Tier 4 is the smallholder farmers' ability to maintain EU market access under EUDR Article 9. The regulation places the compliance obligation on the EU operator placing the cocoa on the market, but the practical effect of that obligation flows back through the supply chain to the cooperative and the individual smallholder, whose plot must be verifiable deforestation-free against the 31 December 2020 cut-off if it is to remain in the operator's sourcing pool. The Sentinel-anchored verifiability evidence is what makes that verification feasible at smallholder scale, where field-only verification is economically unviable and self-certification carries no legal weight under EUDR.

At the societal level, EU citizens and civil-society stakeholders benefit from a regulation whose enforcement rests on verifiable evidence rather than on paperwork-based self-declaration. EUDR was designed to address consumer and civic concerns about deforestation embedded in European supply chains; without a verification mechanism at scale, the regulation would risk operating as another reporting burden rather than as a real disincentive against deforestation. The Sentinel-anchored evidence is what gives EUDR enforcement teeth at the geographic scales the regulation was designed to govern.

[46] Craig Johnston, Jinggang Guo, Jeffrey P. Prestemon, The European Union Deforestation Regulation: Implications for the global forest sector, Forest Policy and Economics, Volume 173, 2025, 103462, ISSN 1389-9341, https://doi.org/10.1016/j.forpol.2025.103462.
(https://www.sciencedirect.com/science/article/pii/S1389934125000413)

The same logic used for the environmental benefits applies here. This would mean that the regulatory benefit attributable to Sentinel-1 is not in meeting the regulatory obligation alone, but also in the shift it enables from a blunt precautionary instrument to a targeted one. EUDR alone would tend to meet its obligation through exclusion, dropping any supply that cannot be proven “clean”. As this would also need to be achieved cost-effectively, smallholders would likely be impacted the hardest. The Sentinel-anchored evidence is what lets the same obligation be met by verifying individual plots rather than excluding whole cooperatives, so compliant farmers stay in the market, and the regulation reaches the geographic scale it was designed to govern. This targeting is a regulatory gain that stems from the satellite evidence rather than from the regulation on its own.

Societal Benefits

The Sentinel-enabled service generates significant Tier 4 societal benefits. The clearest Sentinel-attributable contribution is the protection of smallholders against arbitrary supply-chain exclusion: the same satellite evidence that flags suspect events also support evidence-based clearance of false positives. Without that evidence-based clearance mechanism, smallholders flagged by automated systems would face exclusion pressure that could push them toward less sustainable land-use alternatives.
A second Sentinel-attributable contribution lies in the targeting of restoration and agroforestry support: So-B-Green uses Sentinel-derived flagging and landscape-pressure data to focus these activities on areas where the impact on the farmers and farming-dependent communities would be greatest, rather than spreading the same effort uniformly across the footprint. The restoration and agroforestry programmes themselves exist independently of the satellite layer, but their targeting and reach increasingly draw on it. Same is true for 44+ Local Environmental Committees that SBG supports across its Ivorian footprint, as the precision and credibility of their decisions on forest-risk events improve when Sentinel-derived evidence is part of the evidence base they bring into dialogue with relevant authorities.
Looking from the user perspective, the end consumers of EU chocolate and confectionery products benefit from the assurance that what they purchase was not produced through deforestation. Beyond information disclosure, the welfare argument here rests on the value consumers attach to being able to act on their personal principles through everyday purchases: an EU citizen who holds the principle that they will not consume goods produced through forest destruction gains real satisfaction from being able to fulfil that principle in the normal supermarket aisle. As established in this study, the Sentinel-1 evidence layer is an economically viable enforcement mechanism at smallholder scale and at the cocoa-market price point, which makes this consumer-welfare benefit directly dependent on the Sentinel layer. Without it, EUDR loses the reality

of enforcement, and the consumer principle loses operational meaning at EU-purchase scale.

5.2.5 Other beneficiaries

EU regulatory authorities. The EUDR Information System and the EU Observatory on Deforestation rely on Copernicus/Sentinel as the verification backbone (EUSPA[47]; Climate Action 2025[48]). Without Sentinel, the entire EUDR verification machinery - not just the commercial services built on top of it - would need to be re-engineered. The effectiveness of a major piece of EU environmental legislation is, in operational terms, contingent on a specific publicly funded satellite infrastructure.

Governments in producer countries (Ivory Coast, Ghana). Satellite-based deforestation monitoring provides spatially granular, objective evidence of land-use change that national monitoring systems in both countries have historically lacked. For Ivory Coast, polygon-level compliance data from EUDR-regulated supply chains can be integrated into the national deforestation monitoring framework and supports commitments under the Abidjan Legacy Programme and Ivory Coast's REDD+ programme.

Civil society organisations (CSOs). CSOs such as Global Canopy, Mighty Earth, and Rainforest Alliance gain greater transparency over corporate behaviour through satellite-backed monitoring. With free-and-open Sentinel-1 data, they can monitor commodity-driven deforestation independently of company self-reporting or expensive field investigations and direct their limited investigative and advocacy resources to actors and geographies where the satellite evidence shows real divergence between sustainability claims and on-the-ground outcomes. The shift is from speculative to evidence-based prioritisation. Without the free-and-open Sentinel data, this independent monitoring layer would not exist at the same coverage or would be priced out of CSO budgets.

Financing institutions. Green finance products - sustainability-linked loans, green bonds, supply chain finance - require verifiable sustainability performance data. Satellite-backed deforestation-free certification provides the third-party, technology-auditable evidence that financing institutions require to anchor these instruments. As the EUDR compliance market matures, satellite-backed verification is likely to become a standard due diligence requirement for agri-commodity financing, extending the pattern established by the sustainability-linked credit facility in the palm oil case in previous SeBS.

[47] EUSPA (2024). *EU Space Data Supporting Coffee Industry in the EUDR Context*. EU Agency for the Space Programme. Available at: https://www.euspa.europa.eu/sites/default/files/documents/EU_Space_EUDR.pdf
[48] Berger, K., Herold, M. & Szantoi, Z. (2025). Earth observation as enabler for implementing the EU regulation on deforestation-free products. npj Climate Action, 4, 68. Available at: https://doi.org/10.1038/s44168-025-00276-9

High-profile food companies operating in the EU face ESG scrutiny from investors, banks, and consumers. Sourcing from EUDR compliance value chain analysed for this case allows downstream buyers to make verifiable deforestation-free claims in sustainability reports. The ability to verify rather than self-certify deforestation-free sourcing is a meaningful differentiator as ESG assurance standards tighten. Companies with verified sustainable sourcing credentials also access better terms on sustainability-linked loans and supply chain finance programmes.

5.3 Summary of benefits

5.3.1 Economic

The table below summarises the quantified economic benefits arising from the use of Sentinel data across the EUDR compliance value chain for Ivory Coast cocoa.

Table 5: Summary of headline economic benefits and their projections

Tier	2025 low	2025 high	2027 low	2027 high	2030 low	2030 high
Tier 1 - Disaitek	39,000	39,000	135,000	186,000	222,000	306,000
Tier 2 - So-B-Green	29,500	106,000	44,800	136,600	75,400	197,800
Tier 3 - Africao (scarcity premium)	9,936	35,704	11,040	39,671	17,665	63,473
Total (Tiers 1+2+3)	**78,436**	**180,704**	**190,840**	**362,271**	**315,065**	**567,273**

- Tier 1: €39k benefit in 2025, growing 6-8x by 2030
- Tier 2: €29.5k-106k/year avoided labour cost
- Tier 3: continous annual saving on compliance

5.3.2 Environmental

The case demonstrates two distinct Sentinel-attributable environmental channels operating across the tiers. The first is forest-loss prevention through verifiable cut-off-date compliance: parcel-level Sentinel-1 evidence anchored on 31 December 2020 prevents continued buyer relationships with plots cleared after that date, with the precautionary risk-rating of EUDR Article 9 channelling the avoided clearance pressure across the Ivorian cocoa-growing belt and downstream into Africao's Phase 1 supply (20,000-25,000 tonnes, scaling to 40,000+ tonnes). Additionally, the analysed methodology also serves as an incentive for a sustainable forest management in the

areas neighbouring the cocoa plantations. The second channel is restoration, an outcome also supported via the Disaitek provided service built on Sentinel-1, by which So-B-Green's cocoa-agroforestry programme is supported (around 15,000 hectares by 2026, approximately 60,000 shade trees planted in 2025, with a per-cooperative survival rate of at least 50%). Both channels are directly Sentinel-attributable, the satellite layer being the load-bearing input for Article 9 compliance and the instrumental tool for focused forest restoration activities at smallholder scale, but both also require operator action to translate the satellite evidence into avoided clearance and restoration outcomes.

- Avoided post-2020 clearance across the monitored footprint
- Targetedagroforestry restoration (~15,000 ha; ~60,000 trees in 2025)
- Early warning of clearance at protected-area edges

5.3.3 Regulatory

The analysis of regulatory benefits is naturally anchored in the European Union Deforestation Regulation (Regulation (EU) 2023/1115), which the Disaitek / So-B-Green service directly operationalises[49]. EUDR sets a hard cut-off of 31 December 2020 for forest-cover change and requires every operator placing in-scope commodities on the EU market to submit dated, polygon-level evidence of deforestation-free origin through the EUDR Information System hosted on TRACES NT[50]. The information system itself does not validate the spatial evidence; the burden of proof sits with the operator, and only Sentinel-1's free and globally available (with varying temporal resolution) C-band radar archive going back to 2017 makes that burden meetable at the price points the cocoa market can carry. Non-compliance penalty floors are set at 4% of EU annual turnover under Article 25 of the regulation, alongside confiscation of products and exclusion from public procurement and access to public funding[51]. The same evidence chain has the potential to contribute to different types of environmentally oriented corporate disclosures like ESRS E4 on biodiversity and ecosystems and the TNFD core global metrics, with additional adjacencies with the value-chain due-diligence obligations of

[49] Regulation (EU) 2023/1115 of the European Parliament and of the Council of 31 May 2023 on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation. Available at: https://eur-lex.europa.eu/eli/reg/2023/1115/oj

[50] TRACES NT (Trade Control and Expert System - New Technology) is the European Commission's online platform that hosts the EUDR Information System, the Registry of Due Diligence Statements through which operators, traders, and their authorised representatives submit DDS electronically to the competent authorities. Available at: https://green-forum.ec.europa.eu/nature-and-biodiversity/deforestation-regulation-implementation/information-system-deforestation-regulation_en

[51] Regulation (EU) 2023/1115, Article 25 (Penalties). Article 25(2)(a)-(e) sets a non-exhaustive list of sanctions including fines of at least four per cent of the operator's annual EU turnover, confiscation of the products and the associated revenue, and exclusion from public procurement and access to public funding. Available at: https://eur-lex.europa.eu/eli/reg/2023/1115/oj

the Corporate Sustainability Due Diligence Directive (CSDDD) and the new Ivorian legal frameworks for regulating agriculture and forestry (e.g. Ivorian Code Forestier 2014-427).

- Direct EUDR due diligence via TRACES NT
- Article 9 burden met; Article 25 penalties avoided
- Extended applicability for ESRS E4, TNFD, CSDDD reporting

5.3.4 Innovation and Entrepreneurship

The dimension is anchored in a multi-disciplinary analytical foundation and a service architecture that combines satellite analytics with ground operations across the value chain. Disaitek's EUDR algorithm is built upon the company's deep-learning methodologies, originally validated by NASA and the European Space Agency's PLATO mission in the astrophysics context, applied since 2021 to Earth Observation[52]. Around two-thirds of its current research and development effort goes to extending TropiSCO-style change detection to regions covered by only a single Sentinel-1 orbit. External peer recognition came at the EARSC Product Awards 2024 at EXPANDEO, where Disaitek's platform for monitoring littering and illegal landfills was selected as a finalist. Looking forward, the So-B-Carbon tool under joint Disaitek and So-B-Green development extends the same satellite-plus-field-operations stack into farm-level carbon accounting. Both technical actors are private-sector specialists rather than public institutions, the SeBS-stakeholder types most often associated with higher innovation grades.

- TropiSCO methodology extended to single-orbit regions, enabling continous operational monitoring in tropical regions

5.3.5 Science and Technology

The case generates three Sentinel-attributable contributions to scientific knowledge production. The first is the Messok-Dja study (Disaitek with So-B-Green and WWF Congo, November 2025), which combined Sentinel-anchored land-use mapping with a 669-respondent Bakwélé survey to integrate Indigenous land knowledge into satellite-derived analysis, establishing a methodological precedent for tribal land mapping that travels across geographies. The second is the doctoral research programme at the Institut

[52] Disaitek's deep-learning technologies were developed for exoplanet detection, validated against NASA's Kepler dataset, and integrated into the European Space Agency's PLATO mission programme in the astrophysics context. The company began applying the same foundational technology stack to Earth Observation in 2021. Source: Disaitek company website at https://www.disaitek.ai/

National Polytechnique Houphouët-Boigny in Yamoussoukro, which builds on the Sentinel-anchored compliance methodologies developed in the Ivorian cocoa context to deepen the methodological foundation through PhD-level work resident in West Africa. The third is the joint Disaitek/So-B-Green research pipeline around So-B-Carbon and Cocoa Swollen Shoot Virus Disease detection, which is a second-order partnership effect: the satellite infrastructure made the EUDR-compliance partnership commercially viable, and that partnership in turn enables adjacent applied research. The three contributions sit at progressively weaker attribution levels, from the direct methodological extension in Congo through the doctoral capacity-building to the second-order research-pipeline effect, with none of them constituting a direct Sentinel benefit.

- INPHB doctoral research on Ivorian agroforestry
- Additional development pipelines build on the same techonolgical approach

5.3.6 Societal

The case generates Sentinel related societal benefits in two direct pathways and one indirect. The first direct one is the maintenance of EU-market access for the Ivorian smallholders supplying So-B-Green and Africao volumes: Sentinel-anchored false-positive clearance prevents the precautionary supply-retraction that uncompliant chains would face, sustaining buyer relationships rather than excluding smallholders on a precautionary basis. The second direct channel is the focusing of restoration and agroforestry support on areas where the impact on the environment and communities would be the greatest, with Sentinel-derived land-use evidence as the targeting input. The one indirect channel runs through So-B-Green's 44+ Local Environmental Committees and the broader village-level governance infrastructure: the committees themselves exist independently of the satellite layer, but their priority-setting and reach increasingly draw on Sentinel-anchored land-use evidence.

- EU-market access preserved for compliant smallholders
- Support to farmers and communities focused where impact is greatest
- 44+ Local Environmental Committees using satellite evidence

6 Key Findings and Final Thoughts

6.1 Key findings

This case shows that the value of Sentinel-enabled monitoring lies not only in detecting land-cover change, but in making that information usable within an operational compliance system. The service supports a shift from fragmented, manual, and reactive verification towards a more structured workflow in which geospatial screening, traceability, and field follow-up can be connected more efficiently. The case reframes what compliance infrastructure does in a cocoa supply chain. The pre-EUDR norm was focused primarily on traceability due to technological and economic reasons, as there was no strong policy push. The documented commodity lifecycle went from cooperative receipt back through direct farm purchasing, sustained by paperwork and information gained on the trust basis. The Sentinel-anchored methodology replaces part of that paperwork with independent verifiability, parcel-level satellite evidence of deforestation-free origin against the 31 December 2020 cut-off, generated outside the supply chain and verifiable by any third party from the same public data archive. **The shift from supply-chain documentation to externally verifiable evidence is the qualitative change EUDR brings to the operational setting, and it is the part the Sentinel data makes possible**. Traceability remains in the workflow but no longer does the load-bearing work of compliance defensibility, which is now carried by the satellite evidence layer that any auditor, regulator, or customer can independently re-run.

A central finding is that the benefits extend beyond technical performance alone. The integration of EO-based verification into So-B-Green's broader service offer strengthens decision-making, reduces workload, improves scalability, and reinforces its market credibility. In this sense, the service creates organisational and commercial value as well as regulatory value.

More broadly, the case illustrates why satellite-based monitoring has become essential in this domain. Without such capabilities – offered in a free, full and open manner, the alternative would involve significantly higher costs, far greater reliance on field officers, substantially more time and human effort, and higher uncertainty in the resulting assessments. The significance of the case therefore lies in showing **how Sentinel-derived information can help fulfil sustainability regulation requirements in a more operationally feasible manner across complex smallholder supply chains**.

6.2 The impact of Sentinel data

As in most cases analysed under SeBS and SeBS360, the question of attribution arises: what part of the produced benefit can be attributed to the use of Sentinel data? **For the Disaitek / So-B-Green / Africao service chain, the answer comes close to 100% at the level of the regulatory compliance product**. EUDR requires operators to submit dated, polygon-level evidence of deforestation-free origin going back to 31 December 2020, and no commercial satellite mission provides a free, globally available C-band radar archive of comparable depth. Conventional field-based or optical-only verification cannot meet that burden of proof at the price points the cocoa market can carry and feature a number of technical difficulties for implementation in the tropical regions. **Disaitek's own CEO has stated that without Sentinel-1 their EUDR-compliance service would not have been developed at all**.

Attribution becomes more complex when one moves downstream from the technical evidence-generation function to the operational, commercial, and societal benefits that follow from it. So-B-Green's field operations, cooperative training, and agroforestry programmes are partly enabled by the satellite-driven efficiency gains but rest also on So-B-Green's independent ground capability and on its established relationships with Ivorian smallholders. Africao's continued EU market access through the validated compliance ecosystem is contingent on the Sentinel-enabled evidence, but the commercial decision to invest in compliance ahead of competitors at small-trader scale is Africao's own. At the Tier 4 level, the smallholder protection enabled by the Sentinel-anchored compliance-evidence layer has a clean attribution to the Disaitek service. The farmer-resilience programmes that So-B-Green runs (women-empowerment, savings and loan groups, nutrition training, child-labour monitoring and remediation) are substantially independent of Sentinel data and should not be attributed to it. Same cannot be said to the agroforestry support and So-B-Green offers to farmers and cooperatives, where the optimal implementation of this measure does rely on the data gathered through the Disaitek's Sentinel-1 based service, although this relationship can be understood more as support than enablement.

6.3 Interpretation of results: key assumptions and limitations

The interpretation of results in this case rests on a set of explicit choices that should be flagged. It is also to be noted that the confidence and applicability of these assumptions are not uniform across the value chain. This section sets out the key drivers and assumptions behind each result, states how firm the result is, and marks the boundary within which it should be read, so that the findings can be interpreted correctly and carried into the thematic benchmark reports with the right caveats.

The case is evaluating a service against a regulation that is not yet enforced. Even though originally planned to be enforced from the end of 2024, after a series of postponements the regulation enforcement is now planned for 30 December 2026 for large and medium operators and traders and 30 June 2027 for micro and small operators. Following that the benefit flows described in Section 5 reflect early-implementation positioning by the three actors rather than an established relationship operating on a mature compliance market. Additionally, when enforced, expected waves of operator entry, regulatory clarifications, or revisions will likely require adjustment of the benefit analytics. This is the single largest source of uncertainty in the case, and it applies across every dimension.

The counterfactual against which Sentinel-enabled compliance is evaluated is field-based or optical-only verification at smallholder scale, which the cocoa-market price point cannot sustain. The reasoning behind not using SAR data from a different system or provider is the lack of an alternative C-band SAR satellite system, and consequently the lack of an archive of C-band SAR data, which is globally available and can be dated to 31 December 2020. The alternative approach of using different types of globally available SAR data with existing archive dating to late 2020 (e.g. ALOS-2) would mean that the methodological approach would have to be built on SAR data operating in a different microwave frequency band. Due to the physics of the behaviour of SAR data in different bands, this means that the usability of different-band SAR data (e.g. L-band) cannot be assumed unless proven by additional R&D effort. Consequently, using SAR data of different specifications cannot be used as a source of counterfactual data and the attribution of the compliance product to Sentinel-1 is correspondingly firm.

The quantified economic results carry a narrower evidence base than their precision might suggest. The Tier 1 Adjusted Economic Benefit rests on a single actor's own launch-phase accounts, so its direction is firm, but its magnitude should be read as indicative rather than audited. The Tier 2 Avoided Labour Cost turns on an operational staffing judgement, the two-to-three-fold expansion of the monitoring team, rather than a measured relationship, which is why it is presented as a range. Both are best read as well-anchored order-of-magnitude figures.

Further, it is to be noted that the Messok-Dja study (Disaitek/So-B-Green/WWF Congo, November 2025) is used as a methodological precedent for Sentinel-1 deforestation and land-use mapping. The underlying field evidence is Congolese, but the geographic transferability to the Ivorian cocoa context proves this approach as methodologically sound. Additional thing to note is that the case study does not claim Ivorian biodiversity or community-impact results based on the Messok-Dja figures.

The environmental findings describe conservation value, not a net effect. The farm sample was geographically located close to high-value protected areas, so the

biodiversity and biomass figures characterise the landscapes that EUDR compliance helps hold in place. Further, they are not a statistically constructed counterfactual and cannot be read as a Sentinel-attributable change in the state of nature. The above-ground biomass figure is a single-year 2022 snapshot, so it marks a starting point for future trajectory work rather than a measured gain. These findings are firm as a description of what is being conserved and should be viewed in that light.

The detection layer is bounded by topography and forest structure. Sentinel-1 C-band performance over the Ivorian cocoa belt depends on canopy properties and terrain, and the same service would not necessarily transfer unchanged to denser closed-canopy forest or to strongly dissected relief without further validation. The results should therefore be read as specific to the Ivorian smallholder cocoa context and to landscapes with comparable canopy and terrain, not as a universal claim about the service. It should also be noted that both the service provider and the primary user are in the process of geographical expansion to other continents so the future development of the service might solve this question.

With the exception of the stated economic figures, which are quantified through the Adjusted Economic Benefit and Avoided Labour Cost frameworks, the benefits across the Regulatory, Innovation, Science and Technology, and Societal dimensions are evaluated qualitatively, drawing on interview material with the representative organisation, public regulatory record, and, for the general effects of the regulation, on the published literature on EUDR impacts[53] (Boysen 2025) (Johnston et al 2025). The dimension-level assessments therefore reflect informed qualitative judgement supported by directly sourced information and document evidence, rather than measured outcomes against a quantified counterfactual. Among these, the regulatory finding is the firmest, since it rests on binding law and the defined Article 25 penalties, while science and societal findings are strongly case-specific assessments and should not be transferred beyond this case without further evidence.

Sentinel-1 mission continuity is assumed on the basis that dual-satellite 6-day revisit has been restored, following the 23 December 2021 Sentinel-1B anomaly and the single-satellite operational period that lasted from August 2022 through to the entry into service of Sentinel-1C on 5 December 2024. The 6-day revisit cadence matters for EUDR-grade compliance because parcel-level evidence of land-cover change against the 31 December 2020 cut-off requires dense temporal sampling across the relevant cocoa-

[53] Roldan Muradian, Raras Cahyafitri, Tomaso Ferrando, Carolina Grottera, Luiz Jardim-Wanderley, Torsten Krause, Nanang I. Kurniawan, Lasse Loft, Tadzkia Nurshafira, Debie Prabawati-Suwito, Diaz Prasongko, Paula A. Sanchez-Garcia, Barbara Schröter, Diana Vela-Almeida, Will the EU deforestation-free products regulation (EUDR) reduce tropical forest loss? Insights from three producer countries, Ecological Economics, Volume 227, 2025, 108389, ISSN 0921-8009, https://doi.org/10.1016/j.ecolecon.2024.108389. (https://www.sciencedirect.com/science/article/pii/S0921800924002866)

growing belt. The case interpretation does not anticipate further mission-availability shocks within the case-study horizon, although prolonged degradation of dual-satellite operations would weaken the compliance-evidence cadence at the smallholder scale.

Taken together, these points set the outer boundary of the case. The results describe a single service chain, evaluated against a regulation that is not yet in force, in the Ivorian smallholder cocoa context, dependent on the free Sentinel-1 C-band archive and on canopy and terrain conditions that bound where the service transfers. Within that envelope the regulatory and descriptive-environmental findings are firm, the economic figures are well-anchored but indicative in magnitude, and the qualitative-dimension assessments are informed, case-specific judgements, corroborated where possible by the published literature. It is this delineation, rather than any single headline figure, that should govern how the results are carried into any future studies, reports or impact assessments.

6.4 Final thoughts

The tools and technologies analysed in this study showcase Sentinel benefits which are not limited to a specific EUDR listed commodity nor to the EUDR itself. The same parcel-level record approach can cleanly be expended geographically and utilised for monitoring of deforestation related to other EUDR commodities. Additionally, similar methodologies can generate information important for ESRS E4 biodiversity disclosure under the Corporate Sustainability Reporting Directive, the TNFD core global metrics on land-use change, the due-diligence chains required under the Corporate Sustainability Due Diligence Directive, and the additionality and reversal monitoring expected under the EU Carbon Removals and Carbon Farming Certification Framework. This Sentinel-anchored approach is therefore **not restricted to single-regulation use, but a horizontal compliance tool that travels across the EU sustainability regulatory stack**. The implication for the cocoa case is that the investment Africao, So-B-Green, and Disaitek have made in EUDR readiness can also carry the corporate-disclosure obligations required form large high-profile customer base.

A second observation concerns where the compliance capability actually came from. EUDR triggered verifiability infrastructure not from incumbent traders or platform providers but from a small satellite-data company (Disaitek), a regional-scale field operator (So-B-Green), and a Swiss-based small trader (Africao). The pattern matters for the overall downstream EO community because it suggests that **satellite-anchored compliance capability, is built bottom-up by SMEs rather than top-down by incumbents and large corporations**, and that the EO sector's value proposition is realised through partnership with regional operators rather than through standalone provision.

Looking forward, initiatives and indications that extend the case beyond its current scope. As mentioned before, **Disaitek's Sentinel-based compliance methodology is commodity-agnostic and geography-agnostic by design**, with the same satellite-evidence layer transferable to other origins as the regulation matures across the seven commodities in EUDR scope. Africao is already expanding to other origins such as Ecuador, with the same compliance infrastructure available to support the new origin once volume builds. The joint Disaitek/So-B-Green research pipeline around So-B-Carbon and Cocoa Swollen Shoot Virus Disease detection, which became commercially viable through the EUDR-compliance partnership, opens a path from regulatory infrastructure into adjacent applied research that the satellite layer continues to underpin. Whether the verifiability pattern this case demonstrates becomes the default for future commodity regulations, and whether the EO sector's value proposition continues to be realised through SME-led partnership rather than incumbent provision, are open questions worth tracking in subsequent SeBS360 case studies.

6.5 How does this case relate to others

This case is the first forestry-domain case developed under SeBS360, following four SeBS forestry cases. After examining Sentinels applications for sustainable palm oil production, forest management in Sweden, deforestation-free cacao in Peru, and forest monitoring in Portugal (with the first two being full studies and the latter two being short studies), this case examines how Sentinel-based solution support EUDR compliance in Ivory Coast and extends the benefits and contributions of Sentinel recognised in the Peru cocoa case specifically into a regulatory-compliance setting.

These cases are closely related, highlighting the many co-benefits of Sentinel capabilities and services, which enable efficient and precise monitoring of past and present land-cover change and forest conditions for supply-chain transparency, compliance, environmental monitoring, and risk management. This Ivory Coast case also shows strong transferability to other tropical commodity chains. **The EUDR amplifies this transferability: its deforestation-free sourcing requirements extend across seven commodities** (cattle, cocoa, coffee, oil palm, rubber, soy, and wood), so the methodology demonstrated here for Ivorian cocoa has direct application across the wider commodity scope.

7 Widening the Perspective

The previous sections established the benefits of the service in the specific setting of Ivorian smallholder cocoa. This chapter asks how far those benefits extend beyond that setting. The distinction matters: the **fact that the service can be deployed elsewhere does not by itself mean the same benefits arise elsewhere**. The four sections below set out how the service, its institutional footprint, its market, and its technology base transfer, and the closing section draws these together into the conditions that must hold for each benefit dimension to replicate at a new origin.

7.1 Geographic extrapolation

Geographic transferability along with the commodity agnostic nature of the methodology developed by Disaitek makes geographic extrapolation capacity of this case one of its strongest points. By viewing this aspect in a spatial vertical, each segment guarantees high geographic extrapolation potential.

The technology was developed on Sentinel-1 SAR data, which is a system operating continuously since 2014, placing it comfortably inside the scope of EUDR with enough of a buffer to provide material for comparative analytics of deforestation dynamics before and after even the first mention of the EU initiative to tackle deforestation from 2020[54]. One major significant outage of the Sentinel-1 system happened in December 2021 when an unrecoverable power supply anomaly was detected on the Sentinel-1B satellite. From early 2022 to late 2024 the system operated only with the Sentinel-1A satellite. The single-orbit approach of Disaitek's methodology means that the Sentinel-1B outage does not affect the functionality of the tool, but only the temporal resolution of the analytics. The single-orbit constraint, however, is not a consequence of the outage alone. Even when both Sentinel-1A and Sentinel-1B were operational, many areas over Ivory Coast were consistently acquired from only one orbit direction, ascending or descending, because dual-orbit coverage depends on acquisition planning rather than on the number of satellites in the constellation. Disaitek's methodology was designed for this standing condition. Additional satellites improve revisit, continuity, and redundancy, but the single-orbit capability remains the core of the approach. Since the launch of Sentinel-1C (December 2024) and Sentinel-1D (November 2025) this limitation has been eliminated. With signed development of the Sentinel-1 Next Generation[55], capabilities brought by Sentinel-1 SAR are secured for the future.

[54] In June 2020, the European Commission released a roadmap inviting feedback on a proposal to tackle imported deforestation. This marked the first public step toward what would become the EUDR. Source: https://eudr.co/eudr-timeline/

[55] In June 2026, the European Space Agency has awarded and signed the contract for the development and build for two Copernicus Sentinel-1 Next Generation satellites

Further down the spatial vertical sits the current primary use of the Sentinel-1 based tool as an integral part of the service stack offered by So-B-Green. So-B-Green already operates across both cocoa and coffee in Ivory Coast. The same stack can be deployed in any tropical commodity-producing region where smallholder structures require formalisation to meet the documentation and verifiability standard EUDR sets. The Tier 2 transferability rests on the workflow architecture, not on Ivorian-specific operational needs.

In segment of traders and importers, Africao provides the working proof of geographic transferability. Africao is already expanding to other origins such as Ecuador, with the same Sentinel-anchored compliance infrastructure available to support new commodity origins. The Tier 3 actor's commercial reasoning therefore extends to both new geographies and new commodities, with the Sentinel data layer providing the connective methodological tissue across the actor's expansion path. Even without the regulatory push brought by EUDR, traders like Africao face the need to prove sustainability of commodity sourcing towards high-profile clients further downstream. This client base faces publicity drivers to operate in a sustainable way and are themselves subject to sustainability reporting. These facts provide additional integration capacity of the Sentinel-1 based tool.

Finally, the structural conditions under which the smallholders, EU chocolate manufacturers, EU regulators, and civil-society stakeholders operate are not specific to the Ivorian context. The smallholder structural conditions in West African cocoa share key features with Latin American cocoa, Indonesian and Malaysian oil palm, and Vietnamese, Brazilian, and Indonesian coffee, including dispersed land tenure, smallholder dominance of the producer base, and integration into EU-destined supply chains (Boysen 2025) (Muradian et al. 2025). The downstream EU corporate buyers, regulators, and civil-society organisations face EUDR obligations and stakeholder expectations EU-wide rather than country-by-country, so the benefit cascade established in the Ivorian case translates directly to any other origin geography that feeds the same downstream regulated market.

Geographic transfer is not unconditional. The Disaitek detection layer rests on Sentinel-1 C-band, whose sensitivity to forest-cover change depends on canopy structure and terrain. In denser closed-canopy forest, or over strongly dissected relief, detection performance would need revalidation before the same confidence could be claimed, as noted in Section 6.3. Transfer therefore presupposes a new origin whose canopy and terrain sit within the envelope where C-band change detection is reliable, a condition met across the West African cocoa belt but not guaranteed everywhere the commodity is grown.

In benefit terms, the geographic aspect primarily carries on the economic, environmental, and societal benefits, which arise wherever the smallholder market structure is present. The regulatory benefit is the exception, since it follows the EUDR commodity sourcing countries, rather than the geographical features. The conditions governing each of these transfers are set out in Section 7.5.

7.2 Administrative and institutional transferability

The described Sentinel-1 regulatory compliance verification methodology interacts with EU institutions and producer organisations across multiple administrative levels without requiring institutional reform at any of them, giving a solid basis for transferability along administrative and institutional levels.

On the EU side, the same evidence stream that feeds the EUDR Information System (TRACES NT), reaches every Member-State National Competent Authority and customs verification point through a single shared submission channel, and can easily supply the adjacent EU workflows of ESRS E4 under CSRD, CSDDD due-diligence chains, and the EU Carbon Removals and Carbon Farming Certification Framework. **A single evidence build covers multiple regulatory destinations without separate technical work for each**.

On the sourcing side, the evidence layer is independent of alternative verification schemes and slots into their requirements without institutional reform. So-B-Green's Local Environmental Committees show how satellite-derived evidence can be made actionable at smallholder level when the field-operator role provides the institutional bridge, a pattern that transfers to any producer geography where smallholder governance runs through cooperatives or village structures.

Beyond the EU regulatory perimeter, parallel commodity-origin regulations including the UK's forest-risk-commodity provisions under the Environment Act 2021[56] draw on a similar parcel-level evidence standard, so the verification infrastructure carries directly into these adjacent regimes as they come into force.

In benefit terms, the administrative transferability mainly reflects the regulatory benefit: because a single evidence trail is applicable to several adjacent regimes, from EUDR to ESRS E4, CSDDD, CRCF, and comparable non-EU rules, the regulatory value compounds as those regimes come into force. Section 7.5 sets out the condition this depends on.

[56] The UK's Forest Risk Commodities (FRC) provisions under Schedule 17 of the Environment Act 2021 make it illegal for large businesses to use key forest-risk commodities produced on land used in violation of local laws.

7.3 Improved market and user uptake

The market uptake potential of the Sentinel-anchored compliance infrastructure scales with EUDR enforcement and with the broader sustainability-disclosure stack downstream.

On the operator side, EUDR application from 30 December 2026 for large and medium operators and from 30 June 2027 for micro and small operators will move the bulk of in-scope EU operators and traders into mandatory due-diligence submission across the seven covered commodities. The early-mover positioning Disaitek, So-B-Green, and Africao have established in the Ivorian cocoa context is therefore one instance of a pattern that will repeat across the EUDR perimeter as the regulation moves from preparation into enforcement.

On the customer side, the same evidence stream is usable by any EU corporate buyer with ESRS E4, TNFD, CSDDD, or CRCF reporting obligations, broadening the addressable user base well beyond first placers. Larger traders currently deferring or outsourcing the work, and platform integrators currently positioned as middleware, will need an underlying compliance-evidence source as enforcement matures, with SME-led provision likely to remain a viable route alongside in-house builds.

The principal barrier to broader uptake is the perception of compliance as cost rather than as access to premium downstream relationships. The stated strategic trajectory toward higher-tier customers is actually a working counterexample, showing how the compliance investment converts into commercial advantage once the buyer side rewards verifiability over traceability.

In benefit terms, the market aspect is where the economic benefit scaling potential is the strongest, as enforcement moves the base of actors in the EUDR value chain into mandatory submission and this addressable user base includes every downstream actor carrying a disclosure obligation. Section 7.5 sets out what has to hold for that scaling to materialise.

7.4 Technological evolution and future service development

The service maturation path extends both on the downstream-offering side and on the upstream space-segment side, with near-term developments expected to strengthen performance, usability, and cost-effectiveness over the next development cycles.

On the downstream-offering side, the Disaitek/So-B-Green service stack has several potential directions of development, e.g. tighter integration with the EUDR Information System submission system, direct API access for adjacent regulatory workflows under

ESRS E4, CSDDD, and CRCF so that a single evidence build serves multiple reporting cycles, and field-operator IMS integration including mobile-app extensions for cooperative-level use at the smallholder scale.

On the upstream space-segment side, the Sentinel Expansion Missions add multifrequency SAR capability alongside Sentinel-1. **These missions complement the current service rather than replace it, and the reason is structural**. The EUDR test is historical: it requires evidence of land-cover change measured against the 31 December 2020 cut-off, and the new missions carry no pre-2020 archive. ROSE-L, BIOMASS, and NISAR therefore cannot substitute for the Sentinel-1 C-band record in the core compliance product, and their contribution is forward-looking, improving what can be observed from launch onward rather than what can be reconstructed before the cut-off. It is also worth being precise about the standard they would be improving against. EUDR sets no numerical accuracy threshold. Article 9 requires credible and verifiable evidence of negligible deforestation risk and stays neutral on the technology that produces it. Better sensors do not clear a fixed bar; they raise confidence in the assessment and widen the range of forest disturbance that can be detected.

What each mission would add can be extrapolated, although the magnitude remains an expectation rather than a measured result. ROSE-L's L-band signal penetrates canopy more deeply than C-band, which would improve detection of degradation under canopy and in agroforestry systems (Figure 4 for reference), the settings where C-band is weakest and where cocoa sits, along with coffee and rubber. This mainly strengthens the environmental and regulatory dimensions. ESA's BIOMASS mission, launched in April 2025, carries a P-band radar for above-ground biomass and carbon-stock mapping, which would extend the service from avoided-deforestation evidence toward measurable carbon accounting and the Carbon Removals Certification Framework adjacency. The NASA-ISRO NISAR mission, launched in July 2025, adds further L-band coverage and revisit frequency. Analysed together across C-band, L-band, and P-band, multifrequency SAR would let the methodology separate canopy, sub-canopy, and ground signals in a way single-frequency Sentinel-1 cannot, raising detection accuracy and reducing the false-positive and false-negative burden that currently drives field-verification cost, which feeds back into the economic dimension. None of this changes the core capability, which stays anchored on the C-band archive; the gains are incremental confidence, wider coverage, and new adjacent products.

7.5 Conditions for benefits extrapolation

The transferability set out above is a property of the service. Whether each benefit actually arises at a new origin depends on conditions specific to that benefit. The following states, dimension by dimension, what must hold for the benefit to replicate and how confident that expectation is.

Economic

The economic benefit transfers where two key conditions are present in parallel. In that situation a comparable gap between the cost of Sentinel-enabled compliance and the field-only alternative, and enough EU-bound volume to monetise it exist together. At an origin with low commodity volume destined for the EU market, or where production is consolidated and is done on homogenous areas large enough that field verification is already affordable, the benefit shrinks. Confidence of benefit extrapolation is moderate and rises as enforcement takes hold.

Environmental

The environmental benefit transfers where the commodity is an active driver of forest or biodiversity loss at the new origin, and where an operator acts on the satellite evidence through avoided clearance or restoration (as So-B-Green does). Where the commodity footprint already sits on long-cleared land, the avoided-deforestation value is smaller. As in this case, the benefit describes what is conserved more than a net attributable effect, wherever it transfers.

Regulatory

This is the benefit with highest extrapolation potential, because it depends on a binding rule present at the destination market rather than on local conditions. EUDR applies across the EU market and seven commodities, so the regulatory benefit travels to any origin feeding that market. Where no binding deforestation or traceability rule applies, or the buyer market does not reward verifiability, it falls close to zero. Firm wherever such a rule exists.

Innovation and Entrepreneurship

The innovation benefit is the least tied to local geographic conditions, because it is embodied in the providers' technology and service model. Several of the innovations in fact relax the constraints that bound other dimensions: the single-orbit detection methodology lets the tool operate where only one Sentinel-1 viewing geometry is available, removing the dual-orbit dependence that would otherwise limit coverage. What conditions the benefit at a new origin is therefore not the observation environment but the presence of a provider able and willing to adapt the stack, together with the market or regulatory pull that justifies the R&D costs. Because each innovation push extends a common technology base rather than rebuilding it, the innovation benefit compounds with further extrapolation.

Science and Technology

This benefit depends on research partners and data access being present at the new origin, as the INPHB and Messok-Dja links were here. It is transferable only where a comparable research relationship exists, so it is incidental rather than systematic.

Societal

The societal benefit depends on a smallholder-dominated producer structure, where inclusion and exclusion possibility is comparable to the Ivorian case, and on governance channels such as cooperatives or committees to act through are present. It transfers across West African and Latin American cocoa, and across smallholder oil palm and coffee in South-East Asia, but not to large-plantation homogenous structures where smallholder exclusion is not the operative risk.

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Annex 2: General Approach and Methodology

This case has been analysed as a part of the Sentinel Benefits Observatory (SeBS360), which follows a methodology, established during the SeBS project.

A2.1. Simplified economic benefit projection for Disaitek (2025-2030)

The table below represents the economic benefit projection for Disaitek in between 2025 and 2030 as described in Section 5.2.1. The revenue was calculated based on the blended prices provided by Disaitek, which the assumption that the blended prices would decrease as the monitoring areas increase due to economies of scale. The operating cost is assumed to increase by 4000 EUR per year to accommodate the increase in personnel costs and cloud storage, while the R&D amortisation cost would stop in 2027. The key assumptions for the expansion scenarios per year can be found in "Key driver".

Year	Volume low (t)	Volume high (t)	AEB low	AEB high	Key driver
2025 (actual)	100,000	100,000	39,000	39,000	Launch year; polygon pricing
2026	130,000	160,000	71,000	95,000	Dec 2026 enforcement; partial ramp; tonne pricing kicks in
2027	180,000	240,000	135,000	186,000	First full enforcement year; R&D amortisation expires; So-B-Green full portfolio + direct clients
2028	240,000	320,000	170,000	234,000	Africao phase 2 (40,000+ tonnes/year scale-up scenario); Liberia and Thailand scale-up
2029	300,000	400,000	199,000	274,000	International expansion
2030	360,000	480,000	222,000	306,000	Steady-state; broader EUDR operator base

A2.2 Economic assessment methodology for the So-B-Green case

These four indicators are reported for completeness but **not aggregated** with the headline Tier 2 Avoided Labour Cost (€29.5k-€106k). They illustrate scale and operational value without double-counting:

Indicator / proxy	Value	Rationale for non-additivity
Deforestation Risk Assessment (DRA) Labour Cost Proxy	~334 staff-days ~ **€15,500/yr**	Triangulates the headline ALC is in the right ballpark (DRA portion alone is €15.5k - consistent with €29.5k-€106k total). 5 staff-days/1,000 polygons x 66,800 polygons x €46.36/day. Not added -- DRA is

Indicator / proxy	Value	Rationale for non-additivity
		one task the additional officers would perform; adding it to ALC double-counts the same labour.
Broader manual processing (DRA + QA)	~534 staff-days ~ **€24,800/yr**	Upper manual-processing proxy at 8 staff-days/1,000 polygons. Same double-counting concern.
Screening prioritisation example	8 flagged of 8,000 (0.1%)	One client: 8 cases flagged of 8,000 polygons; resolving them still required substantial follow-up coordination. Demonstrates value of full-dataset screening. Qualitative anchor; not monetised.
Ivory Coast targeted follow-up	10 red-flagged farms x €35/farm ~ **€350/yr**	Anchors per-farm field cost (€35). Sanity check on the stress-test scenario; not a standalone benefit.

The headline ALC alone gives one labour-only number. The proxies (i) triangulate that the order of magnitude is right and (ii) make the screening prioritisation argument concrete. Reporting all in a hierarchy of robustness is methodologically cleaner than picking one. The non-additivity note follows Section 5.2.2's own treatment.

A2.3. Economic benefit projection for So-B-Green (2025-2030)

The table below explains the economic benefit projection for Tier 2 as described in Section 5.2.2.

Year	Portfolio (ha, est.)	Base M&E team	Gross ALC low (2x)	Gross ALC high (3x)	Net ALC low	Net ALC high	Key driver
2025 (actual)	133,600	5	76,500	153,000	29,500	106,000	Launch year; €10,200/officer/yr (company-provided)
2026	140,000	5	76,500	153,000	29,500	106,000	Dec 2026 enforcement starts; portfolio and team stable
2027	150,000	6	91,800	183,600	44,800	136,600	First full enforcement year; new EUDR clients onboarding; partial team growth
2028	175,000	7	107,100	214,200	60,100	167,200	~30% portfolio growth; Africao phase 2 begins
2029	190,000	8	122,400	244,800	75,400	197,800	International expansion
2030	200,000	8	122,400	244,800	75,400	197,800	~50% portfolio growth from 2025; steady-state EUDR market

A2.4 Environmental benefit assessment methodology applied

Methodology

Our analysis is largely based on examining environmental characteristics at cocoa farm locations in Ivory Coast. We collected two sets of farm data. The first set consists of point

location data denoting a sample of farm locations provided by So-B-Green (n=60), located in proximity to areas of conservation value in south-west Ivory Coast, such as protected areas. We complemented this dataset by collecting farm point location data using an analysis of probability of cocoa farms (Renier et al., 2023[57]), collecting 500 randomly located pixels with a probability of cocoa farm threshold of ≥ 80%, allowing us to collect data on the environmental condition of farms across Ivory Coast.

Environmental variables

We collected variables characterising the state of nature and the importance of these areas from a biodiversity, carbon and water conservation perspective. Biodiversity can be mapped in multiple different ways, ranging from species to ecosystem-focused assessments. In this analysis, we used multiple data sources to assess the state of nature, including:

- Biodiversity Intactness Index (BII): The BII assesses human impacts on the abundance of a wide range of species that contribute diverse functions and indicates the average remaining proportion of intact populations of indigenous species in a particular area given the dominant human land uses and activities. Intactness is defined relative to a reference state, typically drawn from remaining wilderness areas or large protected areas. The index accommodates as wide a range of species as possible, with all species weighted equally. The BII is spatially explicit and standardised on a scale from 0 to 100%, where larger values indicate enhanced environmental condition. We used the recently released layer of BII for sub-Saharan Africa, which updates previous assessments of biodiversity condition in the region (Clements et al., 2026[58]).
- Conservation priority rankings: to characterise the relative ranking of conservation priority, we used the areas of global importance for conserving terrestrial biodiversity, carbon and water database (Jung et al., 2021[59]), which provides a score of the most (1-10) to least (90-100) valuable areas to conserve to meet objectives of biodiversity and climate conventions.
- Biomass: We assessed the carbon value of the selection of farms by extracting aboveground biomass values based on the ESA_CCI_AGB database (v6) (Santoro

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& Cartus, 2023[60]). We focused on values for the year 2022, derived from Sentinel-1 along with additional information from other Earth observation sources.

We used point location data of farms provided by So-B-Green and our sample of farms sourced from (Clements et al., 2026[61]) to collect data on the biodiversity layers mentioned above. We used bootstrapping to derive average and 95% CI environmental values across the examined variables. Finally, for the farm sample data provided by So-B-Green, we computed the number of protected areas adjacent within a 2 km radius from the farms' centroid, using data published from Protected Planet (UNEP-WCMC & IUCN, 2026[62]).

[60] Santoro, M., & Cartus, O. (2023). ESA Biomass climate change initiative (Biomass_cci): Global datasets of forest above-ground biomass for the years 2010, 2017, 2018, 2019 and 2020, v4

[61] Clements, H. S., Biggs, R., De Vos, A., Do Linh San, E., Hempson, G. P., Linden, B., Maritz, B., Monadjem, A., Reynolds, C., Siebert, F., Stevens, N., Child, M., Di Minin, E., Esler, K. J., Hamann, M., Loft, T., Reyers, B., Selomane, O., Singh, G., & Skowno, A. L. (2026). A place-based assessment of biodiversity intactness in sub-Saharan Africa. Nature, 649(8095), 113–121. https://doi.org/10.1038/s41586-025-09781-7

[62] UNEP-WCMC & IUCN. (2026). Protected Planet: The World Database on Protected Areas (WDPA). www.protectedplanet.net

Annex 3: About the Authors

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Branimir is a senior consultant at Evenflow. He has more than a decade of experience across the technical, commercial, and policy dimensions of the EO sector, with deep specialism in Copernicus Sentinel applications and downstream service development in the environmental and nature protection sectors. He has a C-level executive background in the downstream EO sector and the experience of working on flagship country-level projects. Within SeBS360 he is serving as a Technical Manager, the lead for the Climate and Biodiversity thematic areas, and contributes to cross-cutting analytical work on the regulatory and commercial pathways through which Sentinel data delivers value to downstream user communities. His broader portfolio at Evenflow includes various ESA commissioned studies and EUSPA market development activities.

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Nazanin is a project manager and consultant at the Brussels-based consultancy Evenflow, where she supports the management and implementation of the SeBS360 project. Before joining Evenflow, she worked within the Horizon 2020 RadoNorm project as part of a collaboration between the Centre for Environmental Sciences at UHasselt and the Belgian Nuclear Research Centre, where she coordinated cross-country research. Her research combined qualitative interviews, surveys, and stakeholder studies to examine the barriers to and facilitators of the adoption of sustainable innovative technologies. She brings to SeBS360 a multidisciplinary background in sustainability, stakeholder engagement, and socio-economic research.

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Duc Tran is an innovation consultant at the Brussels-based consultancy Evenflow. He holds a PhD in socio-economics from Ghent University, where he studied technology adoption and consumer behaviour in agri-food supply chains across European H2020 projects. His research centred on the socioeconomic impact assessment of emerging technology adoption, combining market analysis, choice experiments, and consumer segmentation. He has carried out similar socioeconomic assessment work during both his PhD and his time at Evenflow, bringing directly relevant expertise to the SeBS360 case analysis. At Evenflow he applies these skills to Earth Observation, translating EO tools into real-world applications for a wide range of end users.

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Claire Smith is a consultant at Brussels-based consultancy Evenflow. Her background in natural sciences and sustainability policy led her to work on integrated sustainability assessment and innovation, with a master thesis on the CSRD's implication for the European retail sector. At Evenflow, Claire focuses on market uptake and commercial exploitation of Earth observation downstream applications across climate and biodiversity, renewables energies and infrastructure, agriculture and forestry. She is also specializing in stakeholder engagement, market intelligence, and business strategy, bridging her scientific and policy background to the EO market and future proof business models.

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Alejandro is an early-career conservation scientist with over ten years of experience working in academic, non-profit and industry settings. His research is driven by a strong interest in understanding whether and how conservation efforts succeed, as well as in developing remote sensing applications to help monitor these efforts. He has particular expertise in the development of impact evaluation designs for conservation projects operating in nature-based credit markets. As a postdoctoral researcher at Oxford, he works on the ESA-funded projects Leveraging Earth Observation for Nature Finance (LEON) and ESA SeBS360.

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Joe is a Professor at the University of Oxford, and co-founder of the consultancy Wild Business Ltd. He has spent much of the last 25 years trying to understand how businesses impact biodiversity, and how to monitor and mitigate those impacts towards nature recovery. Joe has a BSc in Physics, an MSc in Environmental Technology, and a PhD in Ecology. He leads the ESA-funded project Leveraging Earth Observation for Nature Finance (LEON), and supports the ESA SeBS360.

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Lefteris is co-founder and CEO at Evenflow and CEO of the Committee on Earth Observation Satellites (CEOS), is a strategy consultant with expertise in programmatic, strategic and business aspects of EU Space Programmes (Copernicus and Galileo). For more than 15 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 contributing to the understanding, measurement and promotion of EO value through multiple activities, most notably the Sentinel Benefits study. He has been advising clients and partners across the full spectrum of the EO value chain, including EU institutions (EC, EEA, SatCen, ESA, EUSPA), universities and private companies.

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