Completion Report

Coffee Vision

Vietnam

NCF9, project no. 1205

Grantee: **Department of Geoscience and Natural Resource Management, University of Copenhagen**

Local Partner(s): **International Center for Tropical Agriculture, Sustainable Management Services Vietnam**

Other Partner(s): **Rainforest Alliance**

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1. EXECUTIVE SUMMARY

Vietnam's massive expansion in coffee production has taken its toll on the environment - increasing risks of deforestation, water pollution, land degradation, climate change and erratic weather patterns - which in turn endangers coffee production. In response to these sustainability challenges, greater attention is being place on sustainability regulations, voluntary standards, and carbon reduction commitments. In order to analyse and monitor the development and document specific coffee production systems, there is an increasing demand for geospatial data reporting.

However, there is a lack of good coffee and forest location data, making it difficult to manage risks of coffee being linked to deforestation. In addition, the lack of an objective and reliable data source on timing of forest conversion to coffee means complete reliance on farmers' self-reporting and official documents. Existing global earth observation datasets do not have the precision necessary for local level analysis and thus run the risk of badly representing the situation in vulnerable remote communities.

The Coffee Vision project aims to close this geospatial data gap, by leveraging satellite imaging and artificial intelligence to create geospatial data layers of deforestation, high conservation value and protected areas, climate projections and carbon storage. These data layers enable the creation of a set of risk and opportunity metrics to help decrease coffee-driven deforestation and thus protect important carbon sinks by reducing the cost and increasing the robustness of third-party certification systems. As the results of the Coffee Vision project, the Terra-i+ web platform (https://www.terra-iplus.org/) emerged as a self-sustaining business model. This platform can be used, when monitoring and evaluating risks of de-forestation related to current and future coffee production. The metrics for the web platform have been identified in consultation with the coffee industry. Also, the lay-out of the web service have been co-developed with potential users.

The Coffee Vision project has Vietnam as the central case. However, the metrics and layout of the web service would be relevant in other contexts. Plans are being developed to expand Terra-+ to other geographies and commodities. Considering the new EU Deforestation Free Regulation (EUDR) such platform could prove very central.

2. ACHIEVEMENT OF RESULTS

2.1 Achievement of outcomes and outputs

Expected outcomes and outputs	**Indicator(s):**	**Achievement of outcomes and outputs:**
Outcome 1.1: Reduced rate of coffee-driven deforestation through Improved quality of information on status and risk of deforestation in the Vietnamese coffee sector	1.1.1 Reduced GHG-emission	Achieved. 38 tonnes CO_2 equivalent, exceeded the target of 9 tonnes CO_2 equivalent.

Output 1.1.1: A baseline map of coffee lands produced based on training and validating of deep learning system with available location data.	1.1.1.1 Info brief on baseline map	Achieved. Produced Info brief 3: Commodity-specific knowledge mapping - coffee in Vietnamese Central highlands.
	1.1.1.2 Intelligent baseline land use map	Achieved. The map is included in the abovementioned Info brief 3.
Output 1.1.2: Coffee climate suitability change maps to 2050s	1.1.2.1 Info brief on suitability map	Achieved. Produced Info brief 4: Climate change impacts on coffee production in the Central highlands of Vietnam.
	1.1.2.2 Intelligent maps of suitability related to climate change adaptation needs	Achieved. The maps are included in the abovementioned Info brief 4.
Output 1.1.3: Deforestation status and future forest-loss risk near coffee lands	1.1.3.1 Intelligent map of deforestation and carbon loss - draft	Achieved. The draft map was included as Annex 3 - Figure 8 in this report.
	1.1.3.2 Info brief on map of deforestation and carbon loss	Achieved. Produced Info brief 6: Deforestation alerts in Vietnamese Central Highlands and associated carbon loss.
	1.1.3.3 Intelligent map of deforestation and carbon loss - reviewed	Achieved. The map is included in the abovementioned Info brief 6. The map is currently displayed in the Terra-i+ web platform created by Coffee Vision project. A screenshot of this map in the web platform is included as Annex 3 – Figure 10.
	1.1.3.4 Intelligent map of risk zones - draft	Achieved. A draft map is included as Annex 3 – Figure 9.
	1.1.3.5 Info brief on map of risk zones and carbon implications	Achieved. Produced Info brief 8: Terra-i+ web platform. Simplifying Agroforestry Sustainability Monitoring.
	1.1.3.6 Intelligent map of risk zones - reviewed	Achieved. The map of risk zone is displayed in the Terra-i+ web platform created by Coffee Vision project team. Screenshot of this map in the web platform is included in the abovementioned Info brief 8.
Outcome 1.2: Increased incentives for the coffee supply chain to prefer deforestation free coffee	1.2.1 Coffee Vision service available and in use by subscribing users	Achieved. Terra-i+ web platform in use by ECOM SMS Vietnam. The platform is to be promoted to other users. Potentially, the platform will be further developed to include other geographies and commodities.

Output 1.2.1 Better understanding of market system around deforestation free coffee in Vietnam	1.2.1.1 Two info briefs on stakeholders and potential users of Coffee Vision	Achieved. Produced Info brief 1: Info Briefs on stakeholder network for sustainable coffee and potential users of Coffee Vision; and Info brief 2: Mapping of potential customers for Coffee Vision service and benchmarking against existing solutions.
Output 1.2.2: Needs assessment and product design for specific verification use cases	1.2.2.1 Info brief on user needs assessment	Achieved. Produced Info brief 5: Info brief on user needs assessment as relates to Coffee Vision metric development and tool design.
	1.2.2.2 Info brief on user reactions to Coffee Vision	Achieved. Produced Info brief 7: Coffee Vision User Reactions.
Output 1.2.3: Provide Coffee Vision as a service for an existing certification process or supply chain	1.2.3.1 Coffee Vision service available and in use by subscribing users	Achieved. Terra-i+ web platform in use by ECOM SMS Vietnam.

At an early stage of the project, a survey was conducted amongst stakeholders within the coffee industry to investigate the need for monitoring and evaluation of the risk of deforestation in relation to current and future coffee production. The survey was followed up by interviews with central stakeholders (including ECOM SMS Vietnam, Rainforest Alliance, Enveritas, Tchibo, and Neumann Kaffee Gruppe). Later in the Coffee Vision project, two rounds of industry outreach have been organized, where representatives from 12 coffee roasters and traders operating in Vietnam (such as Nestle, JDE, Mercon, Sucden, NGK, Tchibo) were interviewed to assess their level of interest as potential users of a web platform. Through this process, we have also shortlisted the most important Terra-i+ metrics from an initial list of 18 potential metrics.

5 maps of risk zones as well as 2 maps of carbon opportunities for agroforestry projects have been finalized to be displayed in the web platform developed by Coffee Vision project. These maps include:

- EUDR compliance: Risks of deforestation since 2020 (jurisdiction level and farm polygon level risk identification)
- Rainforest Alliance compliance: Risks of deforestation since 2014 (jurisdiction level risk identification)
- Recent deforestation events: Risks of coffee farms being linked to recent deforestation (farm polygon level risk identification)
- Climate risk 2030: Risk of future climate becoming less suitable for coffee by 2030 (jurisdiction level and farm polygon level risk identification)

- Water risk: Risk of coffee being closed to water bodies (jurisdiction level and farm polygon level risk identification)

- Shade tree coverage: % of shade canopy cover in coffee land (jurisdiction level and farm polygon level risk identification)

- Potential carbon gain from conversion of current shade system to heavy shaded coffee (jurisdiction level and farm polygon level risk identification)

2.2 Deviations from the planned outputs and activities

During the industry outreach with the coffee sector stakeholders, the project team has come to the conclusion that forward-looking risk maps for potential deforestation was of low priority for the private sector, due to their inability to act on the information. On the other hand, through our discussion, we identified the need for imminent risk informing about concrete deforestation processes putting the industry activities, and especially sustainability certifications, at risk. We therefore decided to re-design the risk management approach provided by Coffee Vision from forward-looking risk to imminent risk and developed the metrics accordingly. These revised risk metrics were included in the web platform.

In response to the recent EU Deforestation Free Regulation (EUDR), we have also identified EUDR compliance as an important risk metric for the private sector.

2.3 Achievement of NCF indicators

NCF core	*Cumulative progress*		*Clarifications/Means of verification*
Number of beneficiaries reached	women	0	This project has – by nature – no beneficiaries as such. Please see number of jobs / people with improved livelihoods instead
	men	0	
	total	0	
Number of people with increased resilience to climate change	women	0	
	men	0	
	total	0	

<table>
<tr><td rowspan="3">Number of people with improved livelihoods</td><td colspan="2">women</td><td>5</td><td rowspan="3">This includes:
Number of people employed by Terra-i+ including developers, web interface designer, GIS analyst and admin to operate the web platform
Number of agronomists of the first paying user. The work of the agronomists will be more efficient, when using Terra-i+</td></tr>
<tr><td colspan="2">men</td><td>18</td></tr>
<tr><td colspan="2">total</td><td>11</td></tr>
<tr><td rowspan="9">New decent jobs created</td><td rowspan="3">full-time</td><td>women</td><td>0</td><td rowspan="9">Number of people employed by Terra-i+ including developers, web interface designer, GIS analyst and admin to operate the web platform</td></tr>
<tr><td>men</td><td>0</td></tr>
<tr><td>total</td><td>0</td></tr>
<tr><td rowspan="3">part-time</td><td>women</td><td>1</td></tr>
<tr><td>men</td><td>1</td></tr>
<tr><td>total</td><td>2</td></tr>
<tr><td rowspan="3">seasonal</td><td>women</td><td>4</td></tr>
<tr><td>men</td><td>5</td></tr>
<tr><td>total</td><td>9</td></tr>
</table>

3. CLIMATE CHANGE

During the project, 3 maps on suitability related to climate change adaptation needs was developed and included together with the methodology in the Info brief 4: Climate change impacts on coffee production in the Central highlands of Vietnam. This has contributed to increasing awareness about climate risks to coffee production.

The climate suitability map was included as a metric in the web platform, which provides an easy to access information support tool to help user prioritize coffee areas in need of climate change adaptation practices.

Furthermore, through the agroforestry project of the first user of Terra-i+, ECOM SMS Vietnam, the project has contributed to at least 38 tonnes CO2 equivalent of carbon sequestration in 2023.

Resilience to climate change is also achieved through water quality protection. Risk to water quality was included as a metric in the web platform, to help users identify coffee areas and farms close to surface water bodies, as such locations present a potential risk to water quality.

While the coffee industry stakeholders have expressed strong prioritization of carbon impact metrics over any other environmental impacts, other stakeholders in the cacao industry have shown more interest in ecosystem services such as biodiversity protection, water quality, and ground water recharge. Terra-i+ underlying technology was used to design and monitor a Payment for Ecosystem Services pilot in Ghana.

4. DEVELOPMENT IMPACTS AND CROSS-CUTTING ISSUES

Metrics in the web platform provides an easy to access information support tool to help coffee traders prioritize intervention areas regarding certification compliance, EUDR compliance and agroforestry project, thus contributing to the reduction of global deforestation and GHG.

By providing tailored information on past and recent deforestation needed in coffee traders' certification internal auditing, the web platform reduces cost and improves efficiency of the certification process. Thus, it enables the inclusion of more farmers into certification program. Certified farmers received not only a premium, but also agricultural advisory on climate resilient farming practices, which improves their livelihoods and resilience to climate change.

In the face of new regulations such as the EUDR, Terra-i+ reduces smallholders' vulnerability and risk of exclusion, by providing localized high precision data that target deforestation within coffee and forest land cover since the EUDR cut-off.

Another use case of the web platform is benchmarking juristrictions and farms by area of coffee under different shade levels, to identify low shaded areas suitable for agroforestry projects to increased shade cover. The combined effects of avoided deforestation and increased shade cover create ecosystem benefits to farmers, surrounding communities, and downstream water users.

There is evidence that current certification and traceability systems have an elite bias by favoring men, given the greater likelihood that they hold land titles and leadership positions. To fill this background gap, Terra-i+ was designed as a digital tool available online, enabling access for users of all genders and backgrounds. However, this is on the basis of the users being digitally literate.

5. ASSESSMENT OF THE RESULTS AND IMPACTS OF THE PROJECT

5.1 Relevance

The metrics in, and lay out of the Terra+ web platform, have been developed in consultation with potential users, coffee traders and operators, in order to make the platform relevant. While these coffee companies are trying to meet geospatial reporting requirements of many voluntary standards, certifications and regulations, they are realizing the lack of good coffee and forest location data. Existing global earth observation datasets do not have the precision necessary for local level analysis and run the risk of badly representing vulnerable remote communities. This make the internal audit processes of coffee companies more difficult, as they cannot target effort of the field staffs towards high risk areas based on existing global datasets. GIS capacity to access geospatial datasets is another problem, as not all coffee companies have the necessary in-house GIS expertise to utilize this data source. The project thus filled both the data precision gap and the capacity gap to access such data, by providing localized high precision dataset and designing a user-friendly interface with metrics tailored to different sustainability use cases.

In addition, the project and the resulting Terra-i+ web platform is in perfect alignment with Vietnam's national development strategies and plans, especially Vietnam's National REDD+ Action Program and the New Rural Development strategies. Terra-i+ provides several deforestation metrics that help assess and take action against deforestation risk at both jurisdiction and farm level, thus it aligns with the deforestation-free agriculture commodity product models promoted by the REDD+ program. Apart from the deforestation use case, the web platform also responds to the environmental and climate resilience focus of Vietnam's largest rural target program, New Rural Development strategies 2021-2030, by providing metrics on water pollution risk, climate risks, and agroforestry project opportunities.

The original objective of the project remains relevant to not only the Vietnamese coffee sector but also to various commodities globally. The needs for geospatial data reporting, which the project responds to, has increased even more during the duration of the Coffee Vision project. This is especially true with the new EU Deforestation Regulation (EUDR), which has heatened the global attention to the problem of environmentally sustainable supply chain in various key commodities. The EUDR is by no means on its own - it is part of a broader governance shift towards regulatory responses to environmental degradation, such as the German Supply Chain Due Diligence Act, UK's Environment Act, US's FOREST Act of 2023, among others[1]. In this context, the project and the resulting Terra-i+ web platform have become more and more relevant for global sustainability due diligence processes.

[1] Verhaeghe, E. and Ramcilovic-Suominen, S. (2024) 'Transformation or more of the same? the EU's deforestation-free products regulation through a radical transformation lens', *Environmental Science & Policy*, 158, p. 103807. doi:10.1016/j.envsci.2024.103807.

5.2 Effectiveness

The expected outcomes and outputs of the project has been fully achieved. Robust methodology to build geospatial data layers, as well as continuous engagement with the coffee sector stakeholders were the key success factor behind the achievement of the outcomes and outputs.

There have been some deviations from the planned indicators as explained in section 2., but the overall outputs and outcomes were still achieved. These deviations were positive in nature, as they have enabled the project to respond more closely to the changing industry needs. The change in mapping approach from forward-looking risk to imminent risk, as well as the incorporation of EUDR compliance metrics has addressed the industry needs for actionable insights and compliance reporting in a timely manner.

5.3 Efficiency

The project has achived all stipulated outputs and milestones within the original time schedule. No extension or cost over-runs were necessary despite several factors that impacted the the project operations.

Among various factors that impacted the operational efficiency of the project, two factors emerged as most significant: Covid19 and cost of web platform development. Covid19 was managed as best as we could, utilising online forms of meeting and data sources to replace in-person meeting and ground validation data. This means that some project resources – especially travel funds – have been under-utilised. In some cases these savings were used to cover additional staff time for development of additional web platform features, and in some cases, these were cost efficiency savings to the project.

The budget required for the development and refinement of the Terra-i+ web platform was larger than anticipated. This additional investment was found to be necessary in order to achieve better design for increased user-friendliness. Through regular user engagement, the project team identified that technical capacity in the target companies was relatively low, requiring a very intuitive and simple 'point-and-click' user interface. In the end, we prioritized the most central features for the first version of the platform, that are enough for a non-specialist user with no geospatial background to be able to use the tool. Any further development and refinement will be funded through the user subscription model and in scaling out to cover more countries.

5.4 Impact

Impacts of this project can be felt not only in Vietnam coffee sector, but also globally for other key agriculture commodities products. Access to localized, high-precision geospatial data for sustainability use cases such as certification compliance, reporting, agroforestry projects, among others has now become easier to access for Vietnamese coffee companies. Globally, the launch of the project's main product, Terra-i+ web platform coincides with the national and global race to meet requirements of the EUDR, providing a timely sustainability solution to meet stakeholders' needs.

Additional impacts of the project include the potential for future projects, which involve designing tools and services for agribusinesses, to harvest the experience from the journey

of Coffee Vision. The key success factor is close engagement and iterative prototyping process with target users to develop metrics that meets the user need, and conveying those metrics within a user-friendly, easy to access interface. The learnings from this project are valuable for the Vietnamese coffee sectors as well as for other commodities and geographies, given that geospatial reporting needs are increasing, and more digital tools are being developed.

5.5 Sustainability

Beyond the project completion, the web platform will continue to be functioning with an active paying user, and plans are being made to attract more user in Vietnam as well as to expand globally and to other commodities. This will enable funds to continuously maintain, update, and refine the platform as well as its underlying data layers.

1) Operation of the current system

Currently, one paying user has signed a service agreement granting access to the tool and support services from the Terra-I team to review, clean and generate reports within the web platform based on their farm-level data. The service agreement renews automatically each year for five years unless cancelled, amounting to a contract value of 25,000 USD. The contract value is enough to cover the physical and cloud servers as well as the personnel time to support the one client, with additional funds to carry over in case of future system updates.

2) Future demand and market expansion

Additional revenues will be required to update the land cover map in 2026, and this requires additional users on the Vietnam platform. For that, we have presented the tool in several conferences, one webinar, and are planning a press release and more webinars. The current pipeline for Vietnam includes 2 potential users who are actively evaluating the tool's fit for their use case and 3 more who have expressed interest but with whom we are yet to set a date for the evaluation demo. Our target is to achieve a minimum of 3 paying users in Vietnam to have the resources to cover the 2026 update along with ongoing maintenance and support.

Beyond Vietnam, demand for geospatial compliance solutions is at an all-time high as a result of the EU Deforestation-free Regulation. In particular, pipeline in the Latin American coffee sector is strong as higher rates of shaded coffee systems results in higher risk that coffee farms will be confused for forest and excluded from the European market. We are likely to start deployment of Terra-i+ in either of Colombia or Honduras before the end of 2024. This will fund creation of the publicly available reference database, land cover map, and the confidential farm-level metrics.

3) Structures put in place for platform maintenance

This subscription-like model required special structures within our legal and financial departments, which have been set up and serve as a framework for future similar knowledge products to follow.

This allows us to set up a retainer agreements with two different web development agencies who can support on front-end design and development updates on an as-needed basis. This allows a flexible cost base that can rise and fall in response to demand and resource availability.

4) Future operating responsibilities

We have not yet found a public or non-profit operator who would be willing to take over the operations of the tool while also ensuring open access to the reference database and land cover maps. However the Inclusive EUDR concept note that is in development includes a plan for creation of a digital public infrastructure system for long-term maintenance that works along within the infrastructure of computing and data systems providers such as Linux Foundation and Google.

5.6 Coherence

The project is coherent and compatible with recent efforts of coffee sectors to improve geospatial data transparency, to respond to increasing demand from standards and regulations. The recent EU Deforestation Regulation has put even more pressure on the geospatial reporting needs, leading to a great increase in the number of traceability and geospatial data solutions. However, currently, there are not a lot of synergies between these solutions. A more standardized approach across different solutions and geographies would be needed to avoid fragmentation.

6. INNOVATION

The web platform, Terra-i+, is innovation in its underlying geospatial data layers, metrics calculation, as well as user interface.

Terra-i+ stands as the cutting-edge of geospatial innovations, derived from satellite imagery with 30 cm resolution and blending advanced deep learning techniques with remote sensing data from the Copernicus missions Sentinel 1 and Sentinel 2. These sophisticated models are not only trained on large datasets but also enriched with local reference data sourced from key areas tied to collaborating companies. These models provide essential components, including precise land cover data and shade tree density assessments within agroforestry systems, which serve as the building blocks required to construct more complex metrics. This unique approach ensures that Terra-i+ delivers actionable, industry-specific metrics while adhering to global standards. Users without any location data can still utilize the tool, thanks to its ability to identify coffee and forest land cover with true positive and true negative rates falling within the range of 82% to 91% accuracy.

Furthermore, Terra-i+ metrics and user interface have been meticulously crafted for the coffee industry, through an iterative and co-creative design process with the coffee industry. Placing users at the centre of its development process, this tool provides metrics finely tuned to meet the specific needs of the industry, ultimately revolutionizing sustainability management in agroforestry supply chains.

7. POTENTIAL FOR SCALING UP AND FOLLOW-UP INVESTMENTS

The Terra-i+ platform emerged from the project as a self-sustaining business model. This was made possible by the freemium paid subscription model, where users can choose to pay an annual subscription fee to access metrics analysis highly customized to their supply chain.

The Inclusive EUDR concept note is being developed to expand Terra-i+'s underlying dataset to 20 major coffee and cocoa countries that make up for >95% of global coffee and cocoa volume. We aim for 5 millions USD to establish a self-sustaining open consortium in these 20 countries. As a result of this consortium, we expect over one million smallholder farmers at risk of marginalization from international deforestation-free regulations to retain market access and become empowered producers in a more sustainable value chain.

The concept note will help marginalized smallholders to maintain market access by including them into the information flow shaping companies' due diligence processes. This will be achieved through three key components:

- First, we will establish a local experts consortium to create a FAIR and inclusive global dataset of reference commodity locations, as well as the shared public digital infrastructure for EUDR compliance. This will faciliate the development of tailored Remote Sensing solutions for private entities' due diligence processes.

- Second, we will identify a series of sandbox landscapes to demonstrate emerging tools for farm-level traceability suitable for the most vulnerable and fragmented element of the commodity chain.

- Third, we will co-create with local and international stakeholder a framework to increase transparency and trust about the data while strengthening long term sustainability of this solution through public-private investment in shared infrastructure for EUDR compliance.

Toward this goal, engagement with computing and data systems providers such as Linux Foundation and Google are being done to develop a series of proposals to secure funding for a substantial global scale-up.

This global Inclusive EUDR consortium is expected to be a self-sustaining model, through revenue from the subscription model for tailored dataset similar to Terra-i+ Vietnam, and from the collection of Partnership Board Member fee.

8. RISKS

a) Risk 1: Covid 19 restrictions on travel. Project meetings and fieldwork cannot be conducted on-site

   Mitigation activities:

   - Regular on-line project meetings have been arranged. Some local project personnel have been able to meet and coordinate on-site.

- Fieldwork in the form of interviews have been conducted on-line.
- Instead of ground truth validating of maps, other digital data have been used for validation.

b) Risk 2: Scope creep increases complexity to the point that we cannot execute the project. When this is the case, we will not be able to fulfil the needs of the potential customers

   Mitigation activities: When collaborating with project partners and potential customers, we prioritised metrics, which are within the scope of the project and ensured that there is an agreed (and limited) process for influencing project scope. If needs outside of the project scope were identified, we tried to develop new projects to cope with these, as done in one case with ECOM.

c) Risk 3: We assume that the industry actors' commitment to deforestation are real and that the actors are motivated to measure and act on their deforestation impact. If this assumption is incorrect, the identification of deforestation (using Terra-i+ web platform) could be seen as delivering 'bad news' and not be embraced by industry players. Also, the commercial market for Terra-i+ web platform may turn out to be very small or non-existing.

   Mitigation activities: The recent EU Deforestation-free Regulation has brought about a marked increase in industry actors' interest towards deforestation free commitment. Indeed, during the M4 period, we have secured one paying user, ECOM SMS Vietnam, as well as attracted at least 2 potential users who are exploring the use of Terra-i+ for their deforestation and carbon monitoring needs. This has proven that the Terra-i+ web platform is relevant for industry actors. In the coming month, we still need to define how best to scale up the Terra-i+ model to other geographies and commodities.

d) Risk 4: The partners we have directly included in the project are not the potential operational users of Coffee Vision. Other potential costumer will have to be identified and included in the development of Coffee Vision

   Mitigation activities: ECOM has turned out to be a customer, whereas RA will not be a direct customer. We have given emphasis to developing a product, of which ECOM will be a paying customer. In addition, contact with other potential customers has started, but has not (yet) resulted in other paying customers. The effort will, however, continue after the end of the project. We foresee that when ECOM has started using the product it will be easier to show case the product to new potential users.

9. MONITORING AND EVALUATION

The web platform will be receiving continuous feedback from users, which will be used to further refine the metrics as well as user interface. Initial feedback from ECOM has indicated the needs for a minor change in user interface, which will be incorporated in the next round of web platform revision.

The project has been clearly defined with milestones, deliverables, and indicators. Those has been monitored inside the requirement of an NCF grant. As demonstrated in section 2, all of these were met within the established timelines.

10. LESSONS LEARNT

Despite Covid19 travel restrictions during the project life, which affected on-ground fieldwork and on-site interaction plans, the project has progressed well, and all major project milestones have been achieved. This was achieved by setting internal on-line meetings and making use of alternative data sources for validating the maps developed.

During the project we have made Industry outreach to selected coffee sector stakeholders and close engagement with target users, who are global traders sourcing from the project geographical area, Central Highlands, Vietnam. This has proven very central for understand the needs of the users, and thus develop a relevant product.

Observing the ECOM local staffs' workflow in-person have resulted in more detailed understanding of the users need and enabled the tailoring of the metric and web platform. The field visits to coffee farms of different shade cover level also provided valuable insights for improvement of the remote-sensing dataset.

Online monthly consultations between ECOM and CIAT have proved to be the most helpful medium for iterative prototyping and testing the web platform in an iterative process. This was especially suitable for the later stages of the Terra-i+ web development.

11. OUTREACH

The results of the project have been communicated through various conference presentations, info briefs, exhibition booth, meetings as well as other means listed below.

- Presentation to the European Coffee Federation (Louis and Tiffany, Feb 2022).
- Presentation to an audience gathered by 4C under the theme: "Protecting biodiversity in coffee landscapes through monitoring tree cover and connectivity":https://www.4c-services.org/trainings-and-events/online-seminars/ (John, Nov 2021)
- Presentation on shade tree detection methods that might feed into Coffee Vision if successful. Event hosted by FAO under the theme "Ways to Develop Agriculture Innovation System via Integration of Industry-Education-Research" (John, based on Paula Paz, Nov 2021)
- Second round presentation to the European Coffee Federation (Louis Reymondin and Tiffany Talsma, Sep 2022).
- Presentation to the EU Agency for the Space Program, Global Navigation Satellite System Service Center (Louis Reymondin, Tiffany Talsma, Christian Bunn, Oct 2022).
- Publication of Land cover map info brief on LinkedIn: The MS2 info brief titled "Mapping coffee in Vietnamese Central Highlands" was published on the Alliance of

Bioversity-CIAT official LinkedIn (January 2023), which attracted great interest from multiple stakeholders. Through this post, we have received many queries from interested potential users in the coffee sector as well as researchers working in related topics.

- Exhibition booth in the USAID Green Invest Asia Forum: Sustainable Land Use in Southeast Asia, to approximately 200 industry leaders, buyers, processors, investors, development finance institutions, donors, and others with business interest in sustainable agriculture and forestry sectors in Southeast Asia (Thibaud Vantalon, Phuong Nguyen Minh, Phuong Luong Thi, May 2023).
- Presentation in Land & Carbon Lab's Summit 2023, during a session titled "Advancing Crop Type Mapping: Innovations for this High-demand, High-difficulty Data" (Louis Reymondi, June 2023).
- Presentation in CGIAR led seminar “Innovations for Inclusion against the European Union Deforestation Regulation." (Louis Reymondi, August 2023).
- Presentation in the Open Source Summit, during the panel discussion *Advancing the United Nations Sustainable Development Goals through Open Source* (Louis Reymondi, September 2023).
- Industry outreach rounds: Two rounds of industry outreach have been organized in 2022 and 2023, where representatives from 12 coffee roasters and traders operating in Vietnam (such as Nestle, JDE, Mercon, Sucden, NGK, Tchibo,…) were interviewed to assess their level of interest as potential users and shortlist the most important Terra-i+ metrics.
- Collaboration with the Linux Foundation to develop a joint proof of concept that positions Terra-i+ as an early adopter of Terrapipe and AgStack project.
- Discussion paper “Navigating the new EU Deforestation Regulation in the coffee industry: Challenges and prospects with remote sensing solutions” submitted. The paper is in review as part of a special issue on ‘Implications of the new environmental agendas for Land Use Policy.

To promote the web platform, website link, a demo account and instruction on using the website will continue to be disseminated to potential users and industry stakeholders.

12. FINANCIAL SUMMARY

Table 1. Project financing per partner

Expenditures (EUR)	NCF	UCPH	CIAT	**Total**
UCPH	124.809,59	51.778,43		**176.588,02**
CIAT	337.658,56		82.498,09	**420.156,65**

Total	**462.468,15**	**51.778,43**	**82.498,09**	**596.744,67**

13. CONCLUSIONS AND RECOMMENDATIONS

Despite Covid19 travel restrictions during the project life, the project has progressed well, and all major project milestones have been achieved. The project has contributed to closing the geospatial data gap in the coffee industry by producing the high-resolution deforestation alerts, land cover, shade cover and climate suitability datasets. Furthermore, it has lowered the capacity barrier to use geospatial data by extracting and summarizing the key information from these data layers to make a simple-to-use platform for agribusinesses.

With subscribed users, the web platform will be a self-sustaining business model beyond the project life, and active plans are being developed to expand Terra-+ to other geographies and commodities. This achievement was only made possible only by the close engagement and iterative prototyping process with target users from the coffee sector in Vietnam throughout the project life.

The results of the project were widely disseminated to industry stakeholders in Vietnam and globally through industry outreach rounds, as well as presentations and exhibitions in various international conferences.

Annex 1 Project completion fact sheet

Project Name:	**Coffee Vision**		
Project no.			
Country:	Vietnam	**Financing:**	
		EUR	**%**
Nordic Partner:	University of Copenhagen	51.778,43	9%
Local Partners:	International Center for Tropical Agriculture	82.498,09	14%
	NCF grant disbursed	462.468,15	77%
	Total		**100%**
Classification:	Combination		
Project cycle:	Project start date: 01/03/2021 Original closing date: 31/08/2023 Actual closing date: 31/08/2023		
Short project description:	The project leverages satellite imaging and artificial intelligence to create deforestation, high conservation value and protected areas, climate projections and carbon storage geospatial data layers. These data layers enable the creation of a set of risk and opportunity metrics to help decrease coffee-driven deforestation and thus protect important carbon sinks by reducing the cost and increasing the robustness of third-party certification systems.		

Project performance:	**Expected Outcomes and Outputs**	**Achieved**	**End-of-project status**
	Outcome 1.1: Reduced rate of coffee-driven deforestation through Improved quality of information on status and risk of deforestation in the Vietnamese coffee sector	Yes	Completed
	Output 1.1.1: A baseline map of coffee lands produced based on training and validating of deep learning system with available location data.	Yes	Completed
	Output 1.1.2: Coffee climate suitability change maps to 2050s	Yes	Completed
	Output 1.1.3: Deforestation status and future forest-loss risk near coffee lands	Yes	Completed
	Outcome 1.2: Increased incentives for the coffee supply chain to prefer deforestation free coffee	Yes	Completed
	Output 1.2.1 Better understanding of market system around deforestation free coffee in Vietnam	Yes	Completed
	Output 1.2.2: Needs assessment and product design for specific verification use cases	Yes	Completed
	Output 1.2.3: Provide Coffee Vision as a service for an existing certification process or supply chain	Yes	Completed

Climate change outcomes and impacts:	38 tonnes CO2 equivalent of carbon sequestration in 2023 The web platform is as an easy to access information support tool to help user prioritize coffee areas in need of climate change adaptation practices.
Development outcomes and impacts:	The web platform is an easy to access information support tool to help user prioritize intervention areas with regard to deforestation compliance and agroforestry project, thus contributing to environmental sustainability. The digital tool is available online, enabling access for users of all genders and backgrounds, providing they are digital literate.

NCF core indicators

NCF core indicator	**Results (quantitative)**		**Clarifications/Means of verification**
Number of beneficiaries reached	women	0	This project has – by nature – no bene such. Please see number of jobs / pec improved livelihoods instead
	men	0	
	total	0	
Number of people with increased resilience to climate change	women	0	
	men	0	
	total	0	
Number of people with improved livelihoods	women	5	This includes:
	men	18	

		total		11	Number of people employed by Terra developers, web interface designer, G admin to operate the web platform Number of agronomists of the first pa
	New decent jobs created	full-time	women	0	Number of people employed by Terra developers, web interface designer, G admin to operate the web platform
			men	0	
			total	0	
		part-time	women	1	
			men	1	
			total	2	
		seaso-nal	women	4	
			men	5	
			total	9	

Annex 2 Updated Results Framework

Expected outcomes and outputs	**Indicator(s):**	**Achievement of outcomes and outputs:**
Outcome 1.1: Reduced rate of coffee-driven deforestation through Improved quality of information on status and risk of deforestation in the Vietnamese coffee sector	1.1.1 Reduced GHG-emission	Achieved 38 tonnes CO_2 equivalent, exceeded the target of 9 tonnes CO_2 equivalent
Output 1.1.1: A baseline map of coffee lands produced based on training and validating of deep learning system with available location data.	1.1.1.1 Info brief on baseline map	Achieved. Produced Info brief 3: Commodity-specific knowledge mapping - coffee in Vietnamese Central highlands.
	1.1.1.2 Intelligent baseline land use map	Achieved. The map is included in the abovementioned info brief 3
Output 1.1.2: Coffee climate suitability change maps to 2050s	1.1.2.1 Info brief on suitability map	Achieved. Produced Info brief 4: Climate change impacts on coffee production in the Central highlands of Vietnam.
	1.1.2.2 Intelligent maps of suitability related to climate change adaptation needs	Achieved. The maps are included in the abovementioned info brief 4
Output 1.1.3: Deforestation status and future forest-loss risk near coffee lands	1.1.3.1 Intelligent map of deforestation and carbon loss - draft	Achieved. The draft map was included as annex 1 in the M2 Progress Report
	1.1.3.2 Info brief on map of deforestation and carbon loss	Achieved. Produced info brief 6: Deforestation alerts in Vietna-mese Central Highlands and associated carbon loss.
	1.1.3.3 Intelligent map of deforestation and carbon loss - reviewed	Achieved. The map is included in the abovementioned info brief 6
	1.1.3.4 Intelligent map of risk zones - draft	Achieved. A draft map was developed during M3 reporting period.
	1.1.3.5 Info brief on map of risk zones and carbon implications	Achieved. Produced info brief 8: Terra-i+ webtool Simplifying Agroforestry Sustainability Monitoring

	1.1.3.6 Intelligent map of risk zones - reviewed	Achieved. The map of risk zone is displayed in the Terra-i+ web platform created by Coffee Vision project team
Outcome 1.2: Increased incentives for the coffee supply chain to prefer deforestation free coffee	1.2.1 Coffee Vision service available and in use by subscribing users	Achieved. Terra-i+ web platform in use by ECOM SMS Vietnam.
	1.2.1.1 Two info briefs on stakeholders and potential users of Coffee Vision	Achieved. Produced info brief 1: Info Briefs on stakeholder network for sustainable coffee and potential users of Coffee Vision; and info brief 2: Mapping of potential customers for Coffee Vision service and benchmarking against existing solutions
Output 1.2.2: Needs assessment and product design for specific verification use cases	1.2.2.1 Info brief on user needs assessment	Achieved. Produced info brief 5: Info brief on user needs assessment as relates to Coffee Vision metric development and tool design
	1.2.2.2 Info brief on user reactions to Coffee Vision	Achieved. Produced info brief 7: Coffee Vision User Reactions
Output 1.2.3: Provide Coffee Vision as a service for an existing certification process or supply chain	1.2.3.1 Coffee Vision service available and in use by subscribing users	Achieved. Terra-i+ web platform in use by ECOM SMS Vietnam

Annex 3 Pictures and screenshots from the web platform developed

Figure 1 Coffee Vision team explaining the Terra-i+ web platform at the USAID Green Invest Asia Forum, 2023

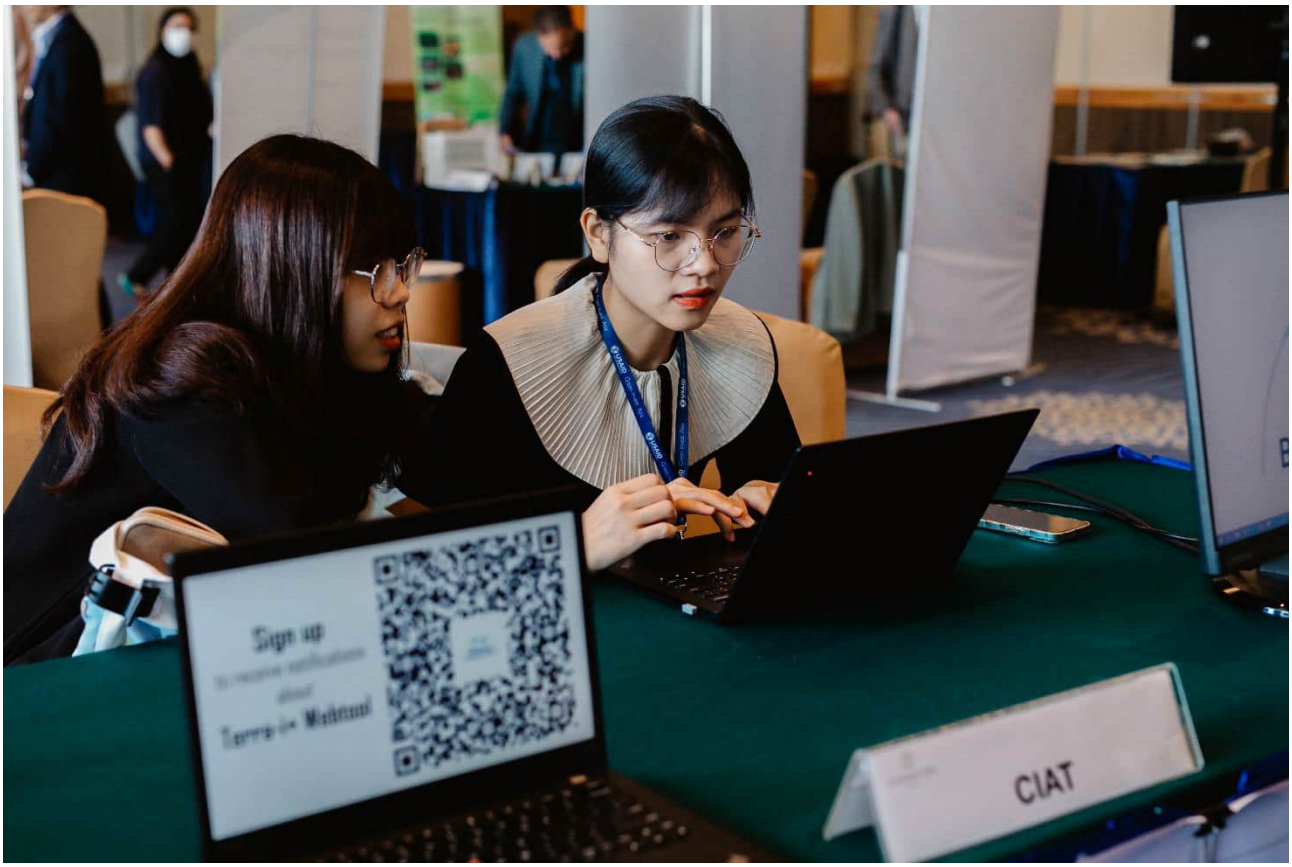


Figure 2 Coffee Vision's exhibition of the Terra-i+ web platform at the USAID Green Invest Asia Forum, 2023

Figure 3 Coffee Vision's exhibition of the Terra-i+ web platform at the USAID Green Invest Asia Forum, 2023

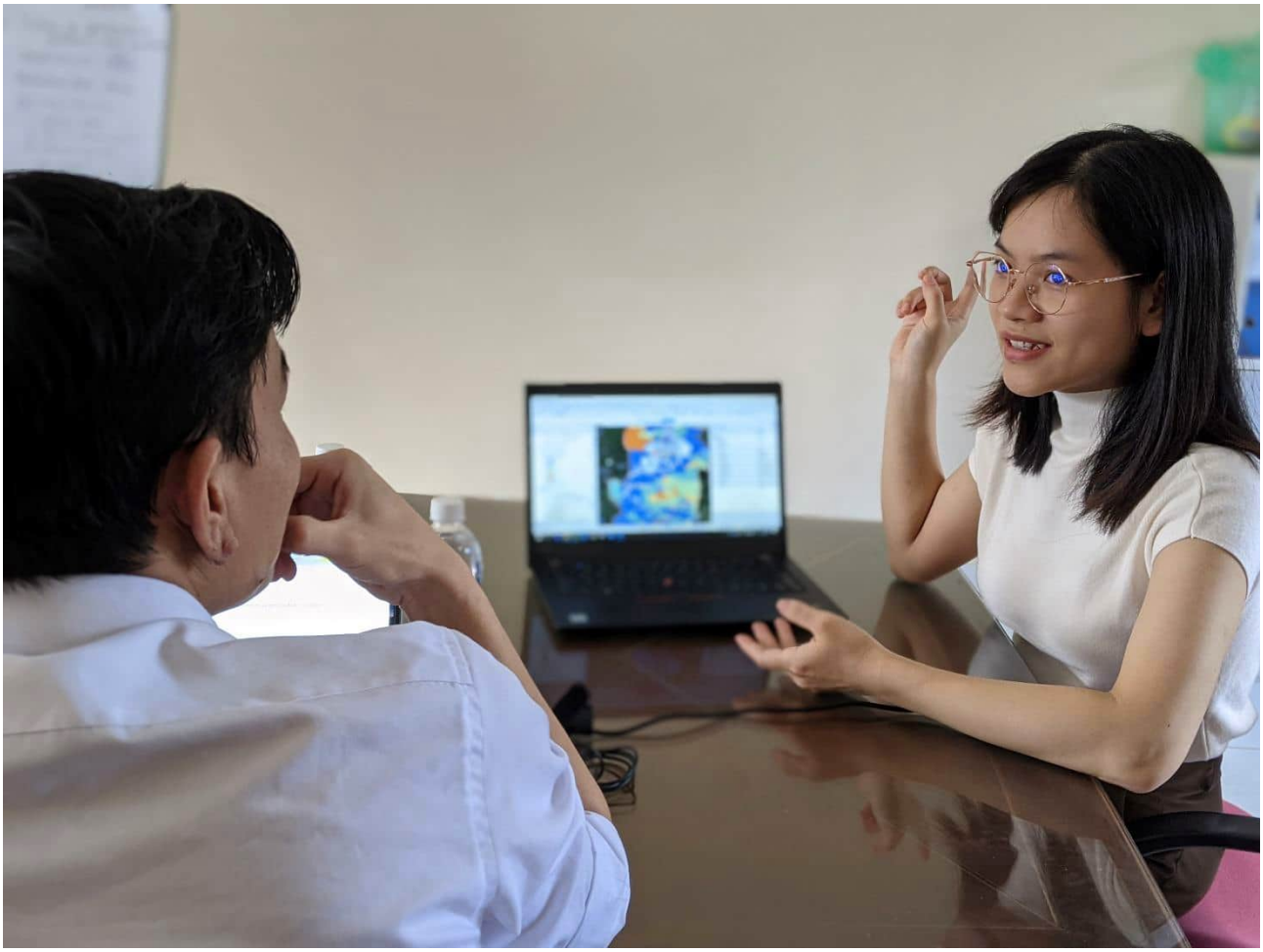


Figure 4 Coffee Vision team discussing the geospatial dataset and metrics with the test user.

Figure 5 Coffee intercropping system during field visit to ECOM farmers

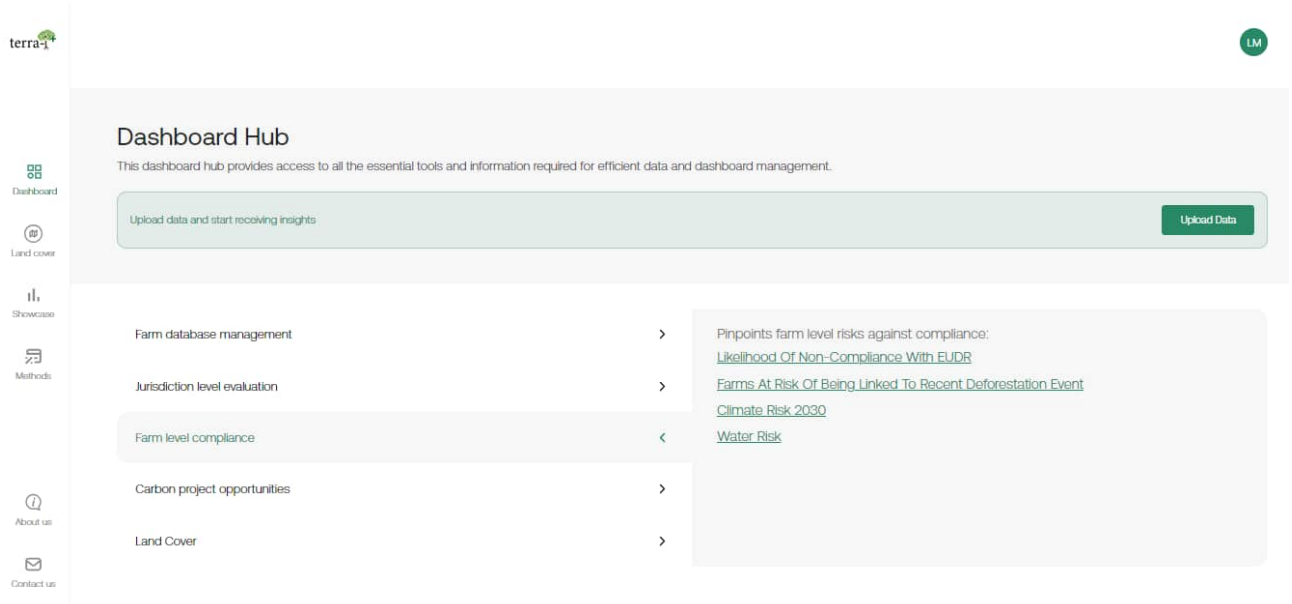


Figure 6 Screenshot of the Dashboard Hub of the Terra-i+ web platform https://www.terra-iplus.org/. User can access all metrics from this page

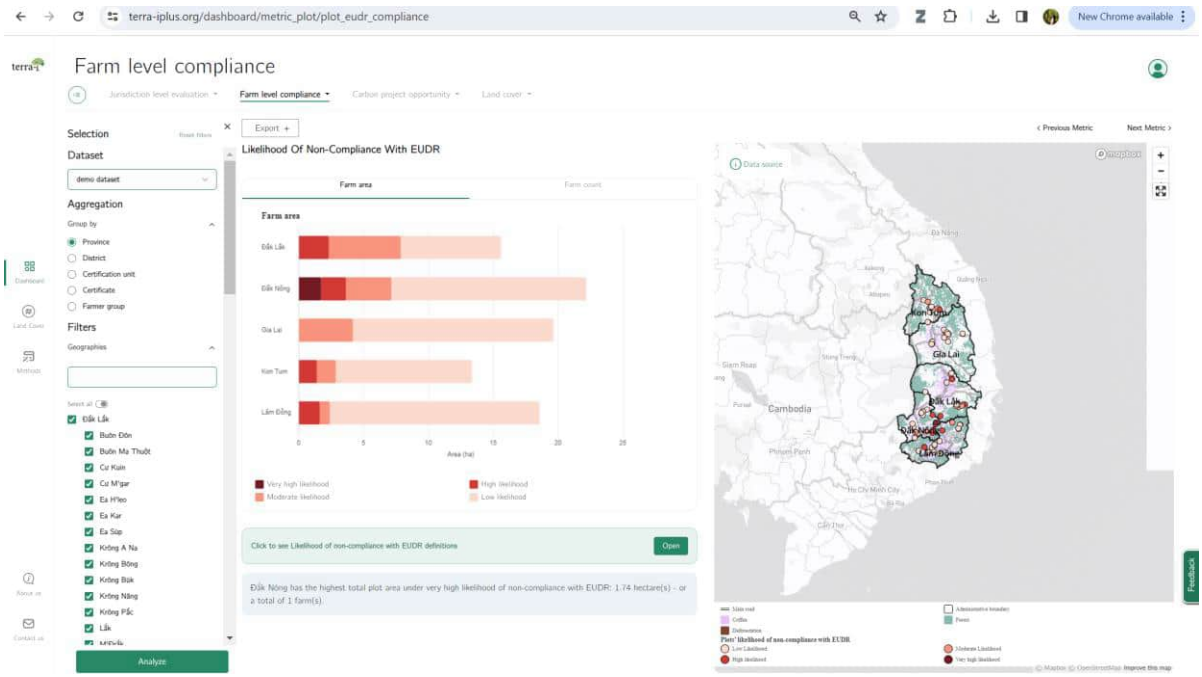


Figure 7 Screenshot of one metric (Compliance with EUDR) of the Terra-i+ web platform https://www.terra-iplus.org/

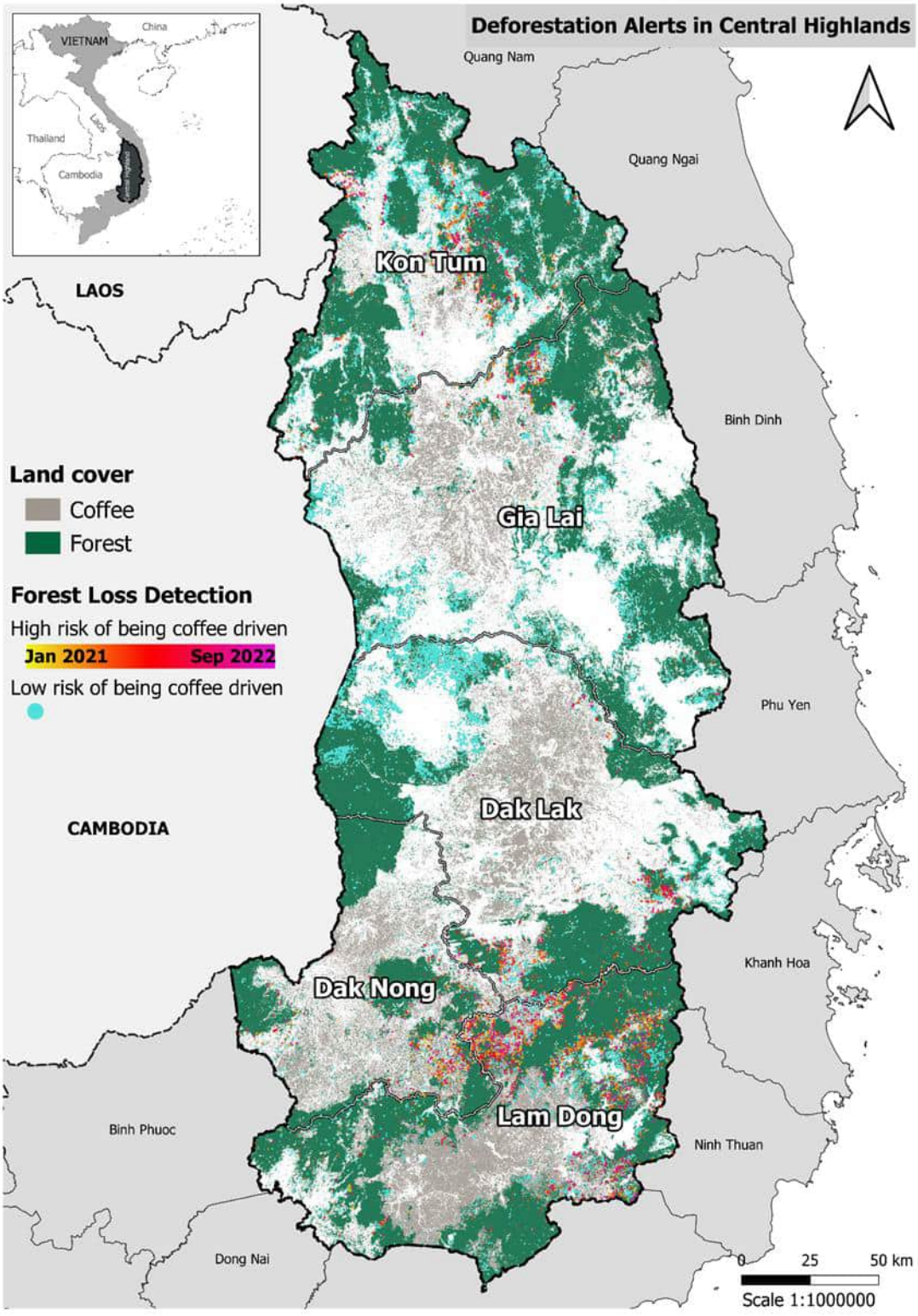


Figure 8. Deforestation alerts and imminent risks map - draft version.

The map presents deforestation alerts with imminent risk levels of being coffee-driven between January 2021 and September 2022. The alerts are classified as low or high risk of coffee-driven deforestation if they are further than or within a buffer of 1km from coffee areas. Colours from yellow – orange to red – purple present historical to most recent deforestation events with high risk of being coffee driven in the covered period.

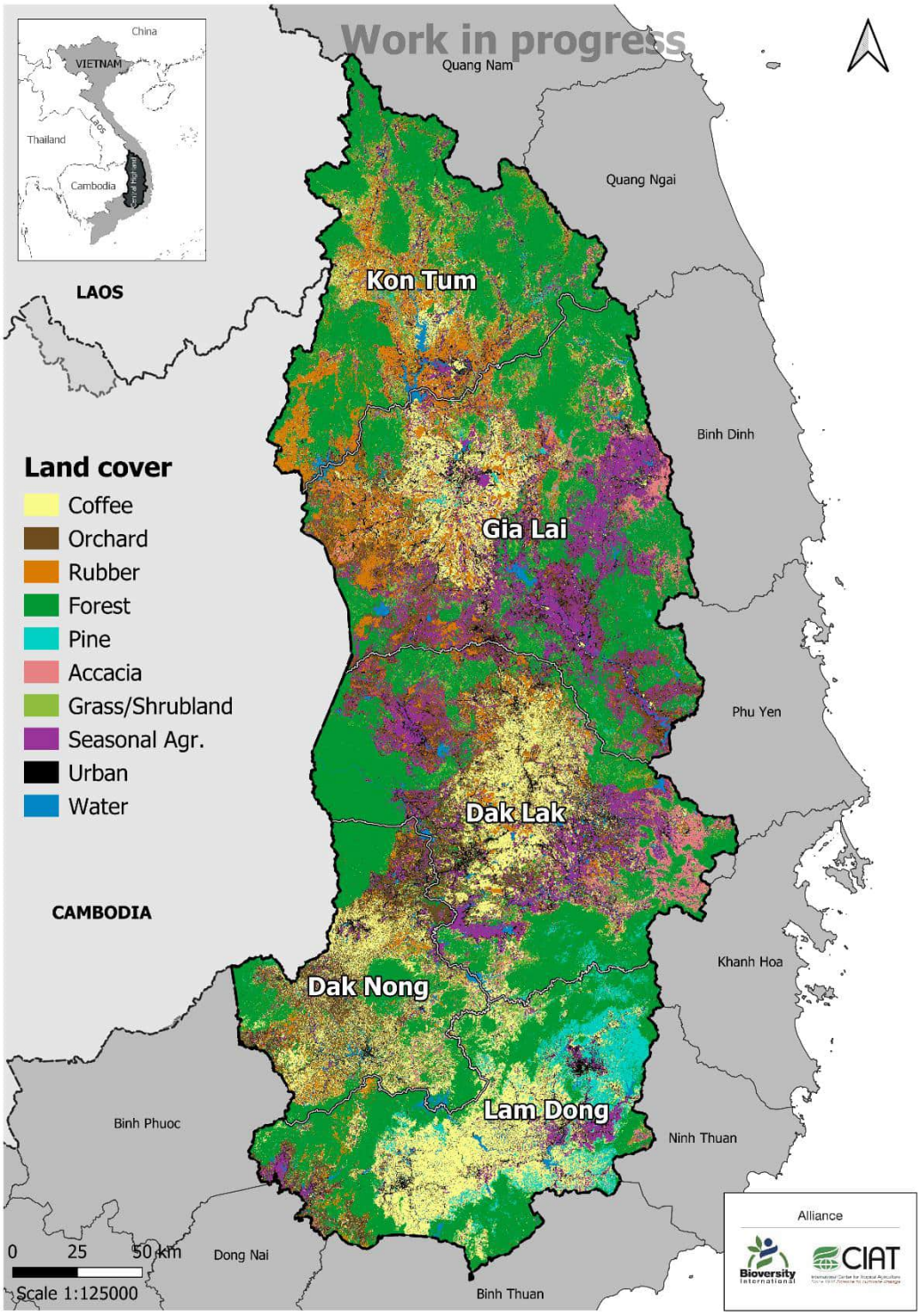


Figure 9 Land cover map – 5th iteration draft version

The 5th iteration version of a map identifying land covers in Vietnam central highland. This shows the extend of 10 different land cover classes. To elaborate this map, we focused our efforts on identifying tree crops, and in particular coffee, as well as natural vegetation such as natural forests and grassland / shrub land. A first validation exercise using national census data and the interpretation of high-resolution imagery was done after this 5th iteration map.

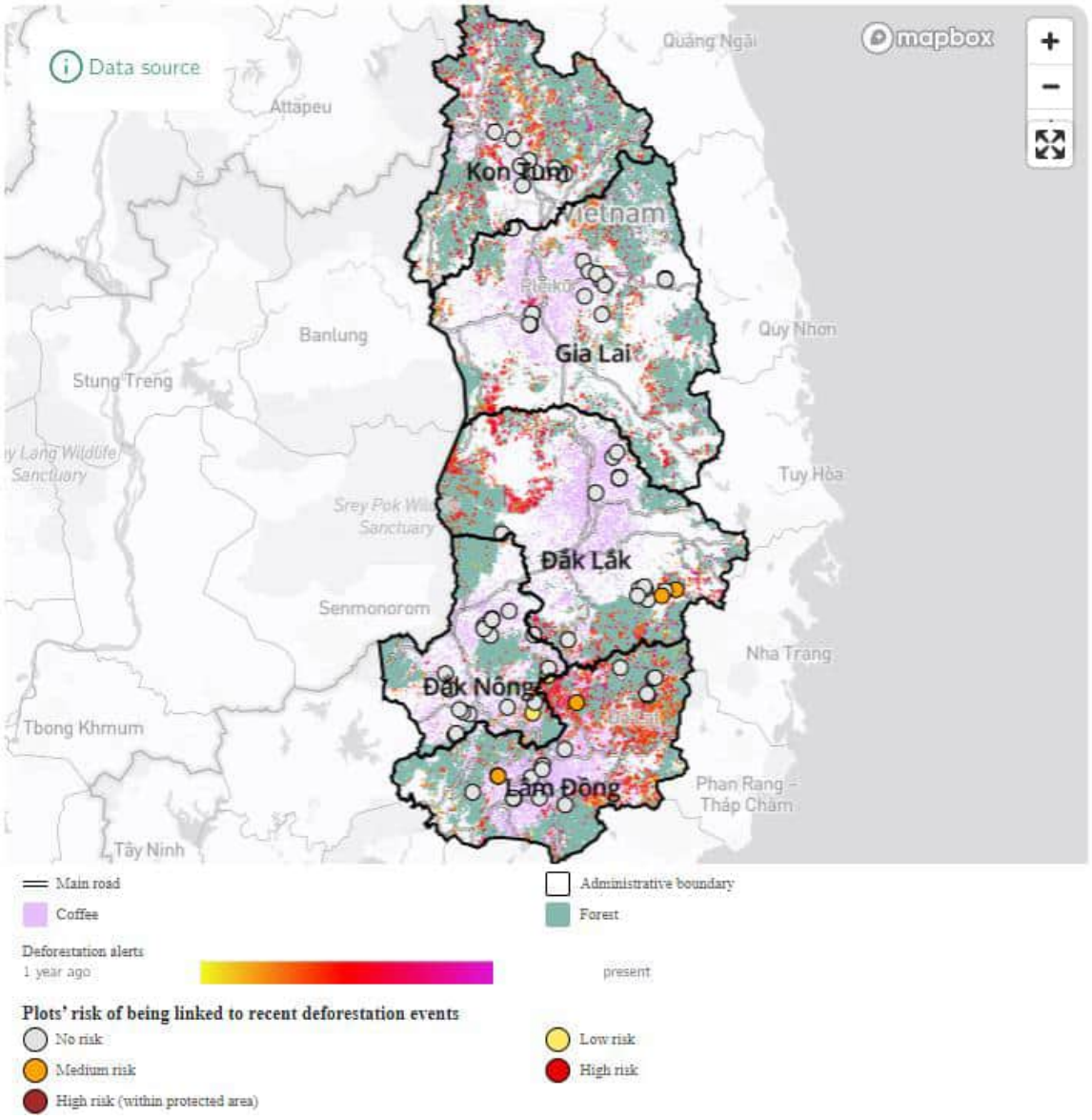


Figure 10. Deforestation alerts map – final version (Screenshot from the Terra-i+ web platform https://www.terra-iplus.org/)

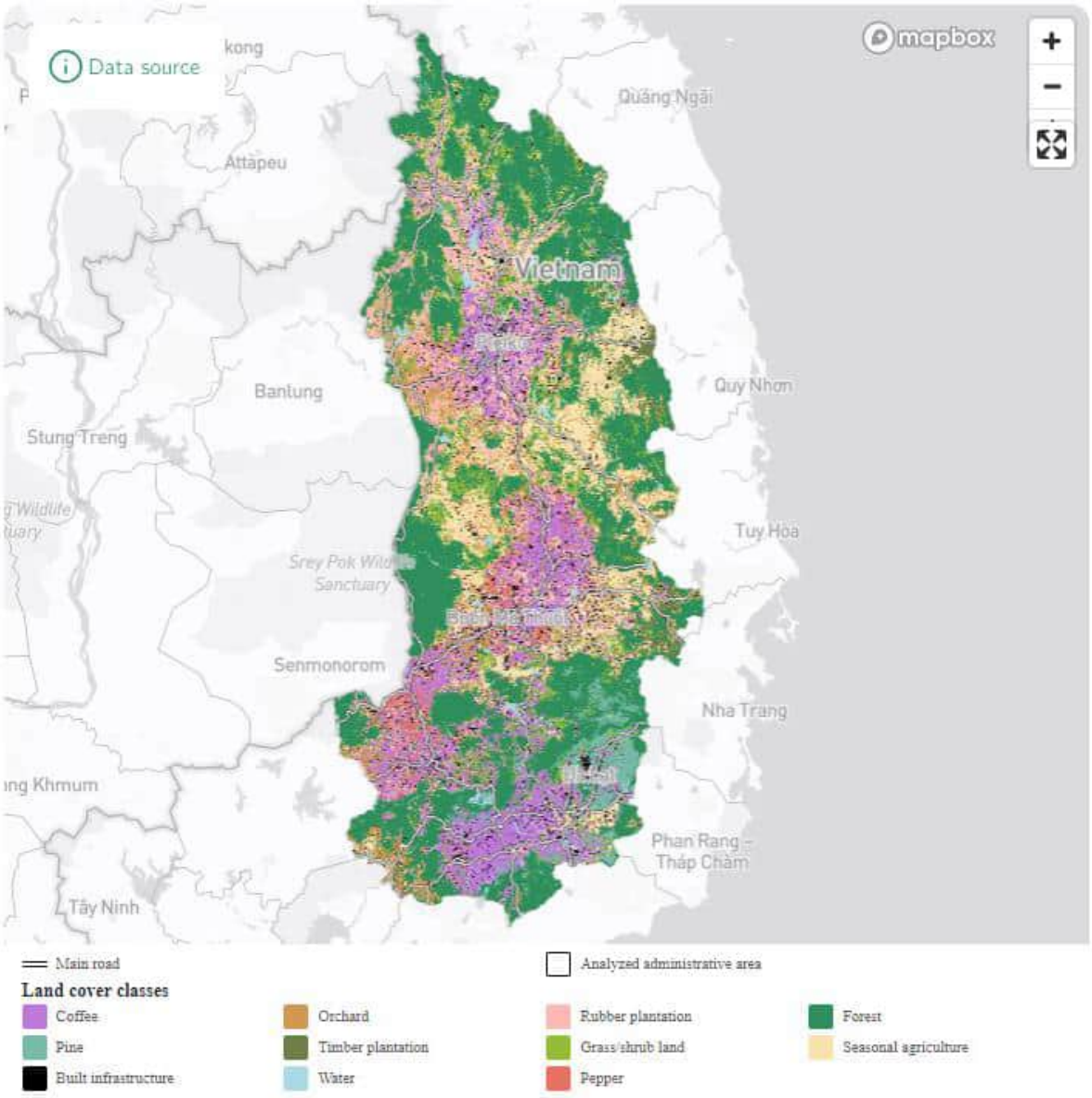


Figure 11 Land cover map - final version (Screenshot from the Terra-i+ web platform https://www.terra-iplus.org/)

Annex 4 Other supplementary deliverables

Link to info briefs[2]:

- Info brief 3: Commodity-specific knowledge mapping - coffee in Vietnamese Central highlands
- Info brief 4: Climate change impacts on coffee production in the Central highlands of Vietnam
- Info brief 6: Deforestation alerts in Vietnamese Central Highlands and associated carbon loss
- Info brief 8: Terra-i+ webtool Simplifying Agroforestry Sustainability Monitoring

Link to Inclusive EUDR concept note

[2] Info briefs 1, 2, 5, and 7 will not be made publicly available, as they include commercial sensitive information of partners and stakeholders. However, the results of info briefs 1, 2, 5, 7 are reflected in the publicly available info briefs 3, 4, 6, and 8.

Annex 5 Impact story

Terra-i+: Customized solution for EUDR compliance and agroforestry coffee in Vietnam

Visit us at https://www.terra-iplus.org/

"We used to estimate deforestation risk and shade tree presence through survey and local experts. Now we can use the more accurate and high-resolution Terra-i+ deforestation and shade tree data for this purpose" - Thuan Sarzynski (Vietnam Sustainability Manager, ECOM Agroindustrial Corp. Ltd.)

The Central Highlands of Vietnam accounts for 93% of all coffee production in Vietnam, which is the second largest coffee producer worldwide. However, Vietnam's massive expansion in coffee production has taken its toll on the environment - increasing risks of deforestation, water pollution, land degradation, climate change and erratic weather patterns - which in turn endangers coffee production.

Widespread attention to this sustainability problem has resulted from the new European Union Deforestation-free Regulation (EUDR). Taking effect from December 2024, EUDR requires any importer of many key commodities into the EU, including coffee, to provide precise due diligence evidence that the product is deforestation-free from January 1st, 2021. This requires not only reliable geospatial farm information but also reliable information on what is considered as forest as of the January 1st, 2021 cut-off date.

While coffee traders and operators in Vietnam are racing to meet these new geospatial reporting requirements, they are realizing the lack of good coffee and forest location data. Existing global earth observation datasets do not have the precision necessary for local level analysis and run the risk of badly representing vulnerable remote communities. Indeed, the EU's Global Forest Cover 2020 map may misclassify more than 50% of known coffee farm locations as forest (Figure 1).

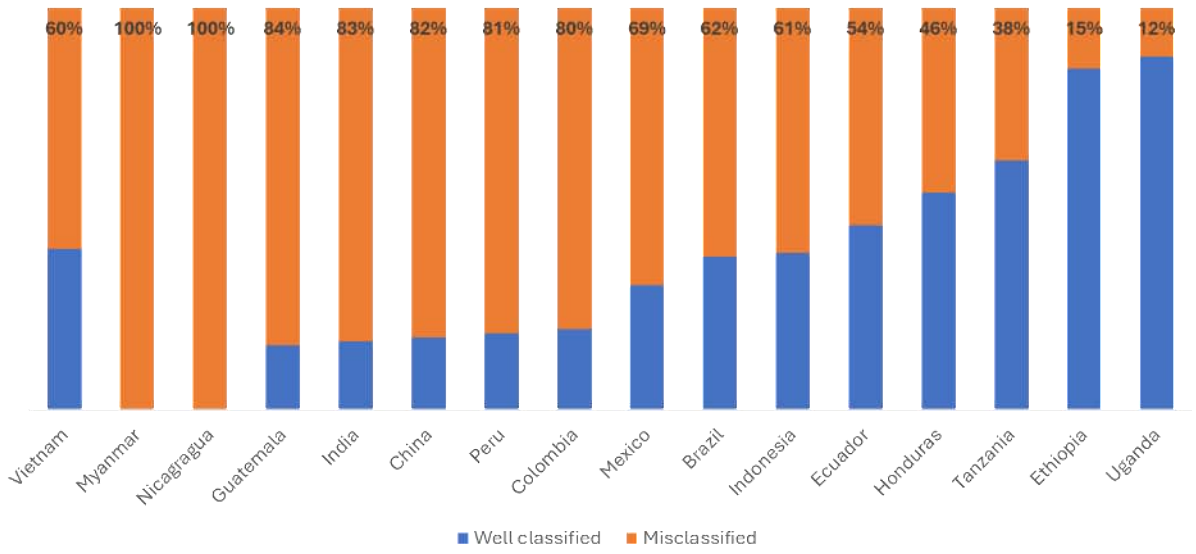


Fig 1. Rate per country of misclassified coffee reference points as forest in EU's Global Forest Cover 2020 (GFC2020)

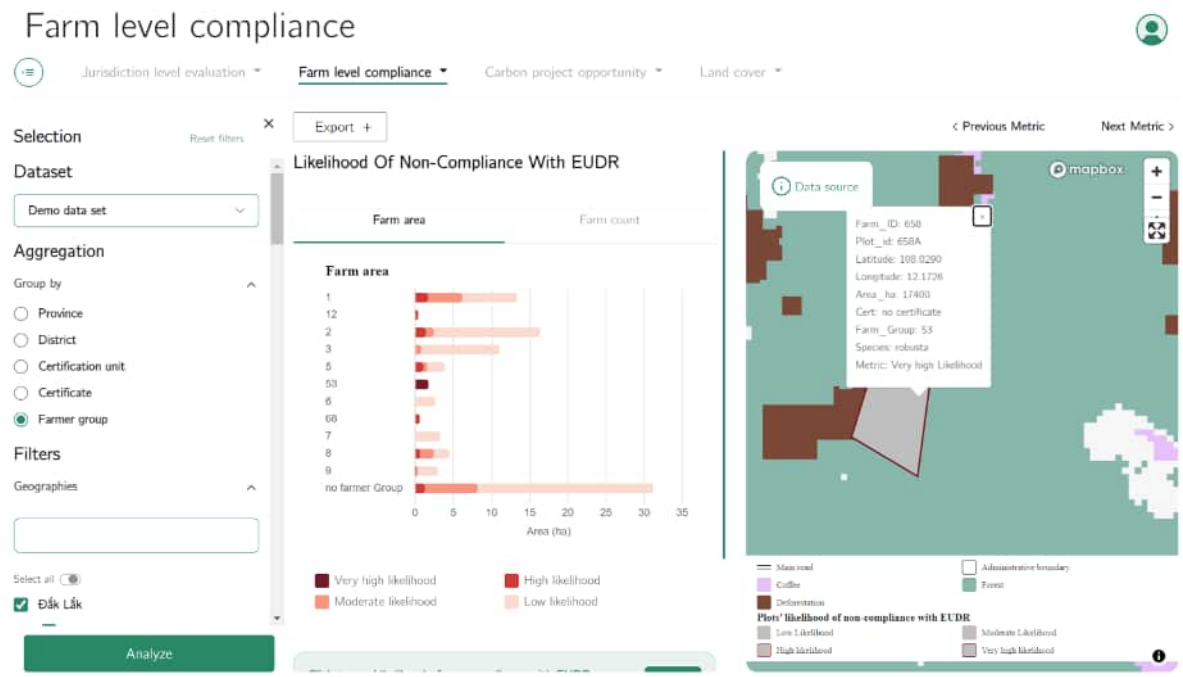
Sources: Ørtenblad et al. Navigating the New EU Deforestation Regulation in the Coffee Industry: Challenges and Prospects with Remote Sensing Solutions. Paper submitted to Land Use Policy.

With an aim to close this geospatial data gap, the Alliance of Bioversity International and CIAT have leveraged nearly 20 years of experience tracking deforestation to develop Terra-i+ (https://www.terra-iplus.org/).

Terra-i+ is a new satellite-based analysis tool that enables coffee operators to assess their supply chain for EUDR compliance, certification compliance (for example, 4C, Rainforest Alliance, Fairtrade, or Starbucks CAFE Practices), determine shade tree coverage, and to find opportunity areas for agroforestry. The tool was the result of an iterative co-design process with institutions, universities, and private sectors partners, such as the Nordic Development Fund, the University of Copenhagen, Rainforest Alliance, and Ecom Agroindustrial.

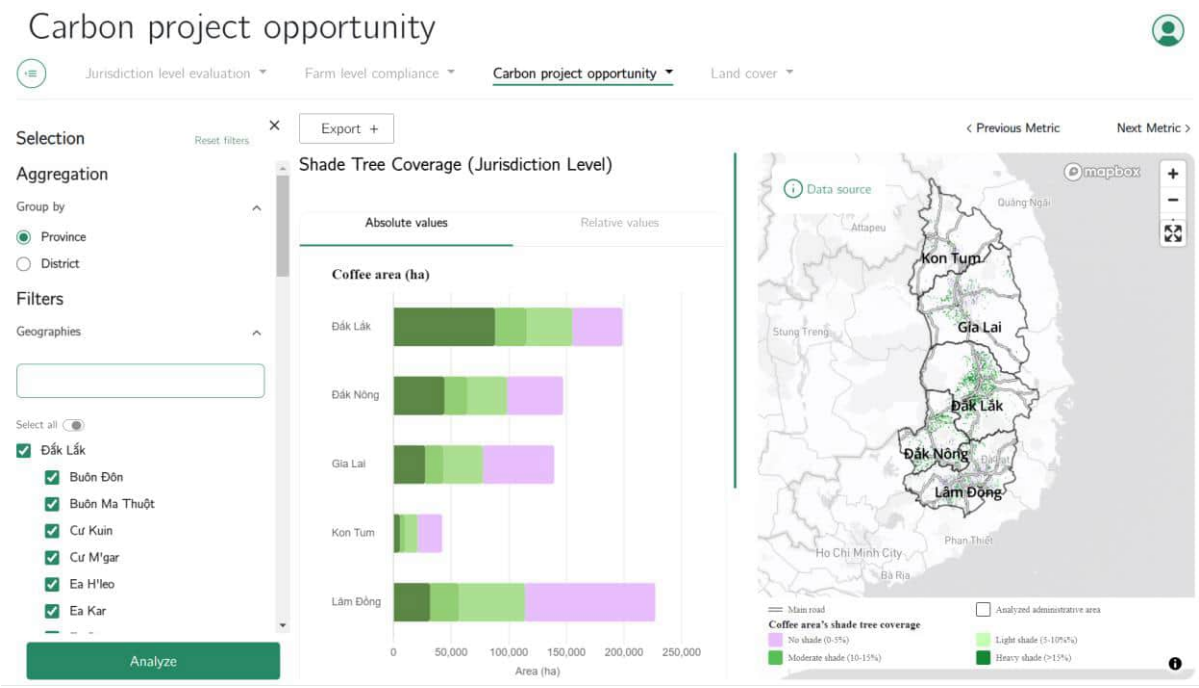
Following strict standards of validation, the Terra-i+ land cover map reaches highest accuracies for the key categories of coffee and natural forest, with precision and recall in the range of 80-90% (Precision assesses the rate of "false positives", which is the probability that any given point on the map is actually what is observed on the ground; while recall assesses the rate of "false negatives", which is the probability that any given point on the ground is correctly classified on the map). Such accuracies are not typical in tree crops such as coffee due to difficulty distinguishing tree canopies from space, making the Terra-i+ land cover map the highest resolution and highest accuracy map among the publicly available land cover maps.

This high accuracy reduces the risk of coffee and forest misclassification, allowing Terra-i+ users to focus only on the true deforestation that happens inside the coffee and forest land cover. Coffee-specific deforestation risk analysis can be done both at the farm and jurisdiction level.



Screenshot ofTerra-i+ metric which analyzes EUDR non-compliance risks at the farm level (farm data is intentionally altered for illustration purposes only). The tool takes diverse farm input data: whether GPS points or polygons of farms.

Another notable use-case of Terra-i+ is discovering opportunity areas for agroforestry. With an innovative method to map density of shade trees, coffee and visible soil, the Terra-i+ team produced a coffee map classified into a spectrum from highly shaded coffee to full sun coffee. The classification of shade level is calibrated specially for the Vietnam context.



Screenshot of Terra-i+ metric which classifies coffee areas into different shade levels, informing agroforestry project opportunities.

In addition to creating high-accuracy localized datasets, Terra-i+ also lowers the capacity barriers to access such geospatial datasets by designing a user-friendly interface and creating tailored metrics, such as EUDR compliance, shade tree coverage, recent deforestation monitoring, water risks, and climate risks. These metrics enable coffee companies to make informed decisions about their supply chain, thus increasing transparency and reducing vulnerability of smallholders in the supply chain.

Terra-i+ is currently in use by ECOM, a world-leading coffee trader with significant operations in Vietnam, to manage their deforestation risks and inform agroforestry interventions.
"We used to estimate deforestation risk and shade tree presence through survey and local experts. Now we can use the more accurate and high-resolution Terra-i+ deforestation and shade tree data for this purpose" – Thuan Sarzynski, Vietnam Sustainability Manager, ECOM Agroindustrial Corp. Ltd., said.

For a demonstration of Terra-i+, contact the Terra-i+ team at support.terra-i@cgiar.org or through the website https://www.terra-iplus.org/about-us.