COFFEE + FORESTS

Piloting improved assessment, monitoring and planning for deforestation free coffee landscapes in Colombia & Indonesia

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CIAT

SUSTAINABILITY CONSORTIUM

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CONSERVATION INTERNATIONAL

EXECUTIVE SUMMARY

Coffee is grown on 10 million hectares of land globally and contributes to the livelihoods of over 10 million farming families throughout the tropics, and like all agricultural products, it needs nature to thrive. Today, nearly every major coffee-producing landscape is under stress—largely impacted by climate change. Climate change could cut in half the total suitable area for coffee farming by 2050. Areas remaining suitable for coffee may shift to higher altitudes – areas that harbor the last remaining intact tropical forests. Coffee has the potential to help conserve these areas or to push into them and drive forest loss.

In light of the changing climate and potential shifts in production areas, understanding opportunities for improved land management in coffee landscapes is key. However, conservation prioritization data and maps are complex and often difficult for local stakeholders to use. Through funding from the Walmart Foundation, together with the Center for Tropical Agriculture (CIAT), The Sustainability Consortium (TSC) and Rainforest Alliance (RA), Conservation International (CI) partnered to develop an innovative approach to mapping coffee production areas in relation to forests and conservation priority areas that enables the coffee sector to better understand the role of coffee in forest conservation, prioritize actions and ultimately, stimulate further commitments to zero deforestation coffee. This was done by:

The effort focused on Colombia and Indonesia – two of the top five coffee producing countries and 30% of global production – where CI has strong government relations and coffee presents both a deforestation risk and opportunity for reforestation and climate adaptation in already converted areas.

Conservation International For over 20 years, Conservation International (CI) has been working with coffee producers and the broader industry to promote sustainable practices that conserve the rich biodiversity of coffee producing landscapes. We have established a renowned coffee program that has directly impacted coffee producers and their communities across 12 countries throughout Asia, Latin America and Africa. In 2015 CI launched the Sustainable Coffee Challenge, recognizing the need to tackle some of the most pressing challenges facing the long-term sustainability of coffee.

Executive Summary

1 ASSESSING THE INTERPLAY BETWEEN COFFEE AND FORESTS

Coffee map layer (CIAT):

In this project, CIAT developed a methodology for analyzing the relationship and assessing the interplay between coffee and forests in production landscapes. They attempted to demonstrate how precise maps of coffee production can be produced at country scale from freely available remote sensed data. Previous mapping was typically restricted to areas where coffee production could be expected to be the dominant land use class. The mixed data quality and availability required significant human validation to accomplish this with respectable accuracy levels, and even with validation, the final product has an overall accuracy of 81%. A key innovation of the work was the use of climate suitability data to delineate the region of interest, making a whole-country mapping computationally feasible for the first time.

Hotspot analysis (TSC):

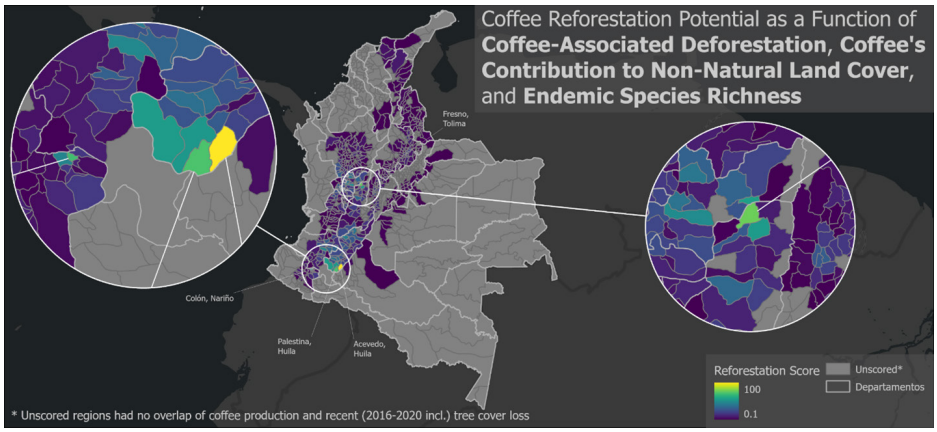
This hotspot analysis intended to model the relationship between observed tree cover loss (i.e., deforestation) and coffee production in the pilot countries Colombia and Indonesia, ultimately prioritizing jurisdictions for engagement/ mitigation efforts. Important to note, the hotspot analysis does not consider economic or political factor, nor does it establish the cause of deforestation, only that it occurred in areas that are now coffee.

- **Hotspot analysis (Colombia):** This model ranks jurisdictions based on the potential return on investment of reforestation projects specific to the coffee sector. This model uses the biotic units (unidades bioticas) from the Colombian MEC dataset (listed below) as the ecological unit of analysis, intersected with the second level administrative units (municipios) to create the base unit of analysis

- **Hotspot analysis (Indonesia):** This model ranks jurisdictions based on the potential return on investment of reforestation projects specific to the coffee sector. The model seeks to maximize the area of coffee-associated deforestation a jurisdiction contributes to an ecoregion as a fraction of the treecover extent of that ecoregion (c. 2010). Each jurisdiction's score is the sum of that fraction across all the ecoregions found in that jurisdiction. Summing the scores for each ecoregion found in a jurisdiction skews the model to those locations that are deforesting multiple jurisdictions, which facilitate broader impact on a variety of ecological resources.

The datasets used for the hotspot analysis include:

	COLOMBIA	INDONESIA
TREECOVER EXTENT	Mapa de ecosistemas continentales, costeros y marinos de Colombia (MEC)	Global 2010 Treecover (Hansen et al., 2013)
ECOREGIONAL EXTENTS	Mapa de ecosistemas continentales, costeros y marinos de Colombia (MEC)	Ecoregions 2017 (Dinerstein et al.)
COFFEE EXTENT	CIAT Coffee Layer	CIAT Coffee Layer
DEFORESTATION	GLAD Global Forest Change	GLAD Global Forest Change



Example of Hotspot Analysis for Colombia

RESTORATION & PROTECTION TOOL WEIGHTING CRITERIA

- Proximity to forests
- Carbon sequestration potential
- Species range rarity
- Proximity to riparian areas
- Fire frequency
- Slope
- Watershed
- Coffee coincident deforestation

Interactive prioritization tool for restoration & protection (CI):

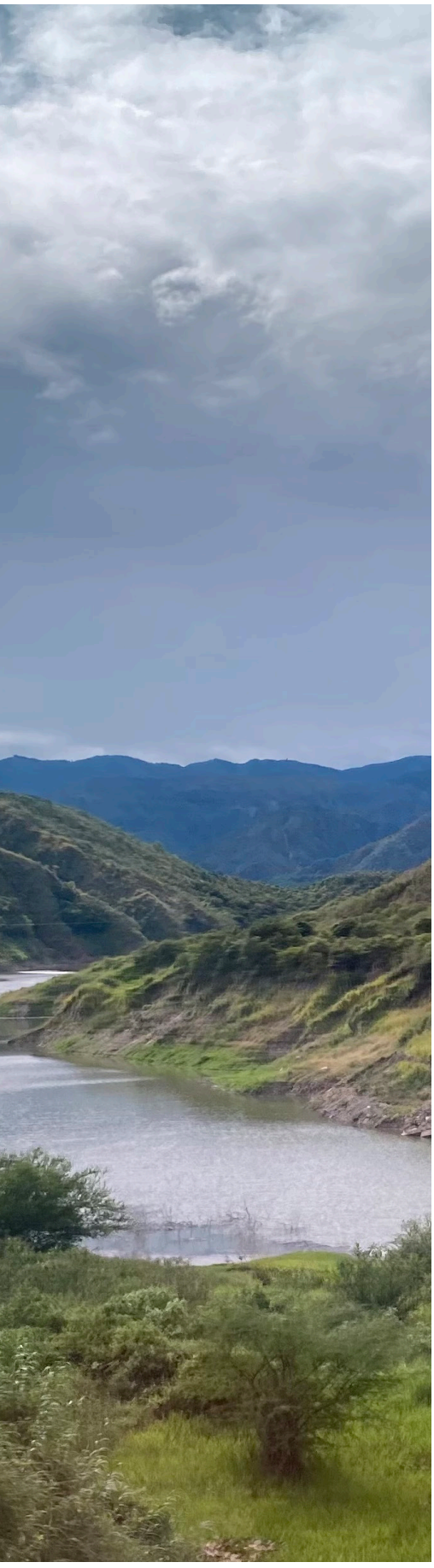
Conservation International developed a tool in Google Earth Engine that allows non-technical users to develop customized prioritization scenarios for coffee areas in Colombia and Indonesia. The tool incorporates the coffee map layer developed by CIAT, as well as the hotspot analysis developed by TSC, in addition to biophysical and socioeconomic data. One tool was developed for Indonesia and one for Colombia that highlights active restoration opportunities such as tree planting, and passive restoration opportunities such as setting aside areas for natural regeneration.

What does the tool do?

- Allows users to identify areas suitable for restoration based on user specifications
- Calculates area in hectares for land available for restoration
- Enables prioritization of restorable areas by weighting pre-selected variables based on expert opinion and displays this on the map for a given region of interest
- Displays high-risk forests in areas suitable for coffee cultivation to highlight forests in need of protection
- Allows users to download a TIF and PNG of three data outputs: available areas for restoration, prioritized areas for restoration, and forests in need of protection.

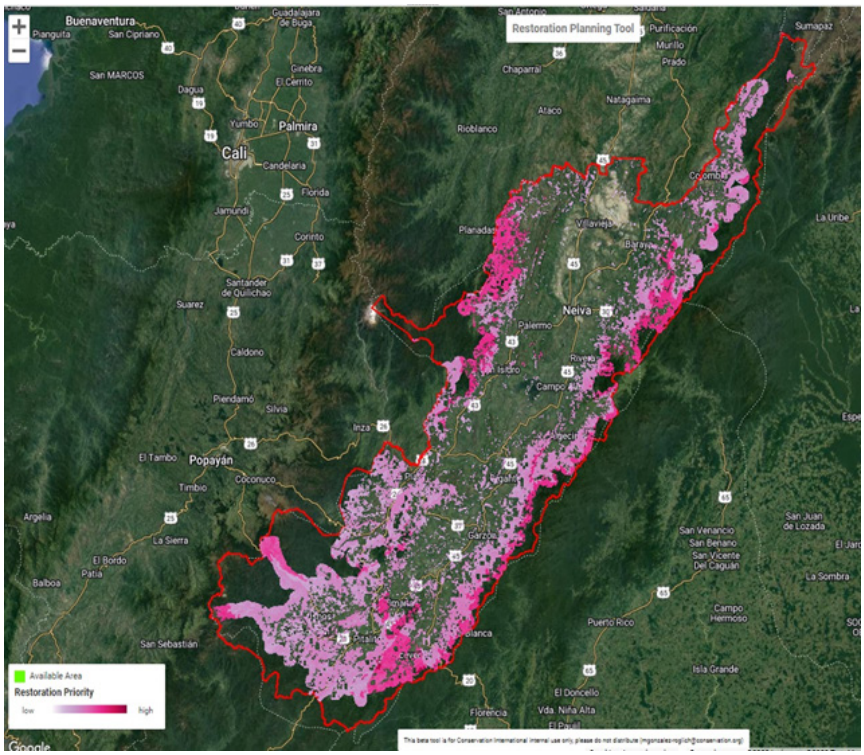
Ultimately the hope for the tool is that government agencies, not-for profits and coffee growing communities begin to integrate the resource into landscape planning efforts and subsequently, fund actions that help protect, manage and restore areas across the two countries.

While the main goal of the Planning Tool is to help prioritize landscapes for restoration and protection efforts based on unique user needs, in addition to allowing users to weight variables from 0-5 based on local interests, there are three scenarios already embedded in the tool that enable quick analysis.



1. **Default Scenario** - Equal variable weights for both active and passive restoration
2. **Carbon Scenario** – Prioritizing carbon sequestration
3. **Hydrological Scenario** – Prioritizing watershed headwaters and riparian areas

After running the analysis with these user-based rankings, users are able to visualize and download a restoration priority and forest protection layer that can help guide stakeholders as to where to focus restoration efforts.



Example of Hotspot Analysis for Huila, Colombia

Scientific paper on remote sensing methodology[1]:

CI began the coffee mapping component with a literature review to understand the current state of mapping coffee systems using remote sensing. It reviewed potential methodologies, and associated challenges, including the Lidar fusion method that was selected for creating the coffee maps. Subsequently, a paper was written in collaboration with partners from CIAT, TSC, and academia who actively research coffee mapping technology and methods. Our findings were published in an open-source journal to ensure greatest access by researchers. In this publication we outlined various past remote sensing methods used to map agroforestry and coffee landscapes, and we described the most promising remote sensing methods and tools to continue coffee mapping into the future. The literature review provided general recommendations of best practices for mapping coffee, and CIATs methods followed these recommendations. Similar methods had been tried before in the literature (although on a smaller scale) and had been successful, which supported the basis for CIATs methodology.

Citation: Hunt, D. A., Tabor, K., Hewson, J. H., Wood, M. A., Reymondin, L., Koenig, K., ... Follett, F. (2020). Review of Remote Sensing Methods to Map Coffee Production Systems. Remote Sensing, 12(12), 2041. doi:10.3390/rs12122041

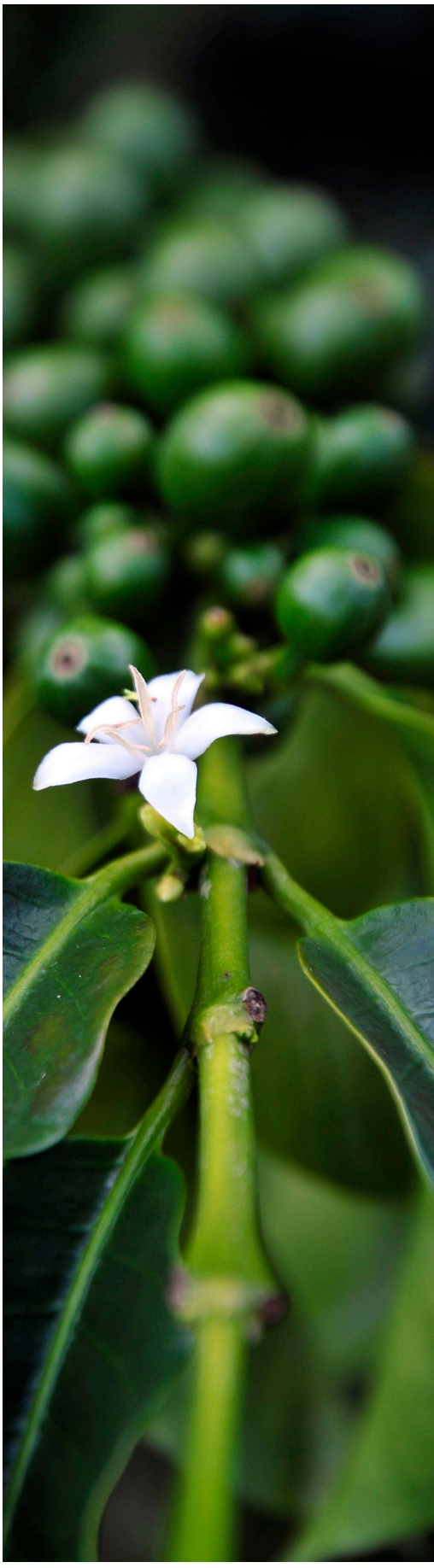
1 Remote Sensing | Free Full-Text | Review of Remote Sensing Methods to Map Coffee Production Systems (mdpi.com)

Key Learnings:

- **There is a reluctance to share data across the industry from governments, companies, and NGOs alike, which made producing a coffee map challenging.** This reluctance could be due to concerns about competitors accessing data, data rights and privacy of farmers, or even a concern around what additional clarity on coffee areas could lead to tracking of forest changes, which could put a negative light on coffee. This is an area where the coffee sector lags well behind other commodities (ie: palm oil, soy, etc) and could be a tremendous opportunity to incentivize greater transparency across the coffee sector.
    - **In Colombia, many stakeholders have access to privately collected spatial data on coffee that has not been made public. The mapping produced in this research should be seen as an incentive for those with finer scale data to be more transparent in sharing it with other stakeholders.**
    - **In Indonesia where coffee has generally not been mapped locally by stakeholders there was a greater appreciation for this level of mapping and insights, especially among government stakeholders.**

- **Where coffee data is available, it varies greatly in quality and is often not suitable for the purpose of remote sensing analyses.** Therefore, any analysis requires substantial human investment to generate clean data from such initial reference locations.
    - The majority of the coffee data available appears to be collected where the farmer was interviewed to describe supply chains, including the farmhouses, primary processing facilities or collection station rather than the coffee fields where it was grown. Such data is valuable to describe flows of coffee and identify broad origins but cannot be used to train remote sensing classification models for coffee plots
    - Additionally, plot-level data that is collected to estimate coffee area, remotely observe pest and disease outbreaks, etc. was similarly not usable for this purpose as it sometimes classified adjacent forest, riparian areas or minor patches of other land cover as ‘coffee’ area.

- **Existing and available coffee data does not represent the diversity of coffee-growing systems, especially in terms of shade,** etc.in sufficient quantities per type to adequately train the model to map these systems. Without that, some systems may remain unmapped or mapped incorrectly. Ideally this would be complemented with sufficient non-coffee data to train the model to correctly identify forest or other tree crop systems.



2 PILOTING FOREST ASSESSMENT METHODOLOGY AND ACTION PLANS IN COLOMBIA AND INDONESIA

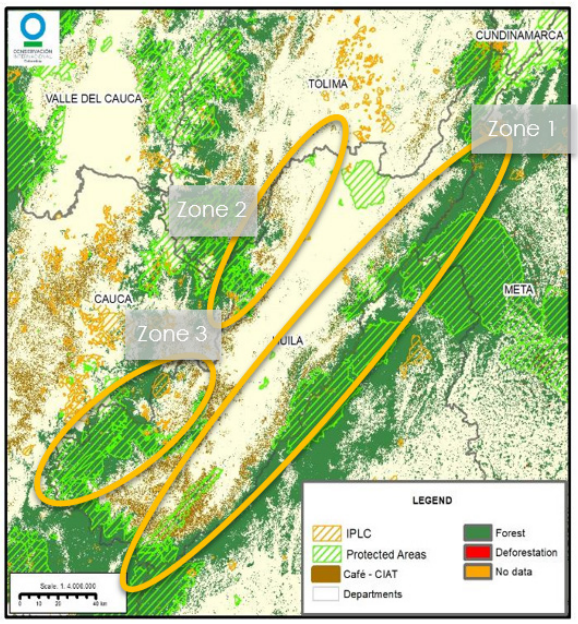
Taking the tool as a basis for conversation, the CI Colombia & Indonesia teams led workshops with local stakeholders to prioritize actions for the landscapes of Huila and Antioquia and North Sumatra, respectively. During the spring and summer of 2022, workshops were conducted in the three landscapes to discuss investment priorities in the places. Additionally, as part of the workshops, stakeholders determined how to weight each criteria in the planning tool, as shown in the table below.

CRITERIA (1=LOW, 5=HIGH)	HUILA	ANTIOQUIA	NORTH SUMATRA
PROXIMITY TO EXISTING FOREST	5	5	5
CARBON SEQUESTRATION POTENTIAL	5	4	5
SPECIES RANGE RARITY	4	3	5
PROXIMITY TO RIPARIAN AREAS	5	5	5
FIRE FREQUENCY	4	5	4
SLOPE	4	5	5
WATERSHED	5	4	5
COFFEE COINCIDENT DEFORESTATION	5	5	-
PEATLANDS	-	-	4
PROXIMITY TO IMPERVIOUS SURFACES	-	-	4

Huila:

Colombia's department of Huila covers 1.9 million hectares (ha) with more than 1.2 million residents and is the largest coffee producing department in the country including highly rated quality coffee. In 2020 over 140k ha were dedicated to coffee production. For the analysis of the landscape, the areas prioritized by stakeholders were taken as a starting point. These areas were then analyzed with the National Plan for Ecological Restoration and the delimitation of protected areas at the national, regional and municipal level as additional information to visualize their ecological importance. As such, three zones were identified as priority areas, with zones 1 and 2 with the highest priority. Zone 1 includes seven of the thirteen municipalities in the Andean-Amazon Corridor: Colombia, Tello, Gigante, Guadalupe, Acevedo, Garzón and Algeciras. Zone 2 includes Aipe, Neiva, Santamaría, Palermo, Teruel, Íquira, Nátaga and Tesalia) and is connected to the department of Tolima (municipalities of Planadas and Ataco). All of these, with the exception of Neiva, have important altitudes optimal for coffee production.

Stakeholders present at the workshop included: Corporacion de Alto Magdalena (CAM), SENA, representatives from the municipalities of Colombia and Tello, Coocentral, Departmental Coffee Committee, CREER, Starbucks, SKN Caridecafe and SEDAM.



Zones prioritized by local stakeholders in Huila

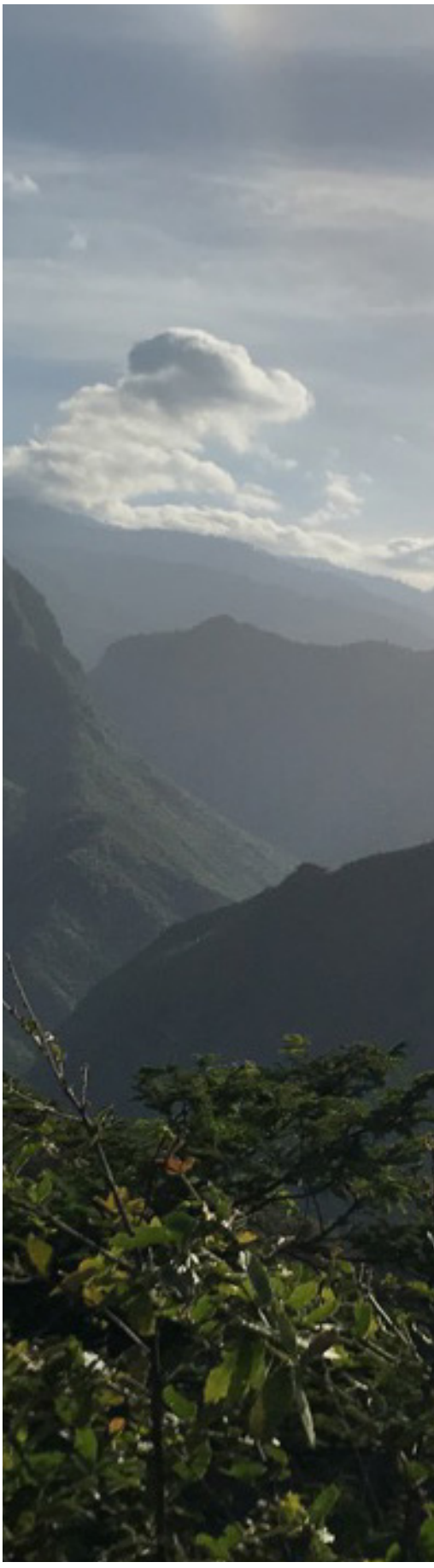
Antioquia:

Antioquia is the second largest coffee producing department of Colombia with over 97K hectares dedicated to production out of the total 6.4M hectares. The population is 6.6M also ranking as the second most populous department in the country. When reviewing in detail the Southwest of Antioquia, stakeholders highlighted that the most important areas for intervention include nearby zones in Farallones del Citará Protective Forest Reserve (municipalities of Andes and Ciudad Bolívar) and to the Cuchilla Cerro Plateado and Alto de San Jose Integrated Management Regional Districts (municipalities of Salgar, Concordia and Betulia), Cuchilla Jardín Támesis (municipalities of Caramanta, Jardín and Támesis), Nubes Trocha Capota (municipalities of Pueblorrico, Jericó and Tarso). These areas of high importance are relevant to the ecosystem connectivity of the landscape.

Stakeholders present included in prioritization meetings include: Corantioquia, Antioquia's Departmental Government, SENA, GAIA - Antioquia, Solidaridad, COOCAFIM, Antioquia's Coffee Cooperative, Expocafe, Grupo Argos Foundation, Verde Agua Corporation and Proaves Foundation.

Priority actions were similar in both landscapes and can be summarized as:

1. Installation of infrastructure for coffee processing with a smaller environmental footprint
2. Off-farm ecological restoration and reforestation
3. Development of conservation agreements linked to productive issues
4. Strengthening of existing protected areas
5. Strengthening the work of multi-stakeholder platforms as a setting for the construction of sustainable landscapes (Coffee, Forest & Climate Agreement).
6. Strengthening of organizational capabilities
7. Environmental education (support with entities such as SENA, professionalization of activities in the field with coffee).



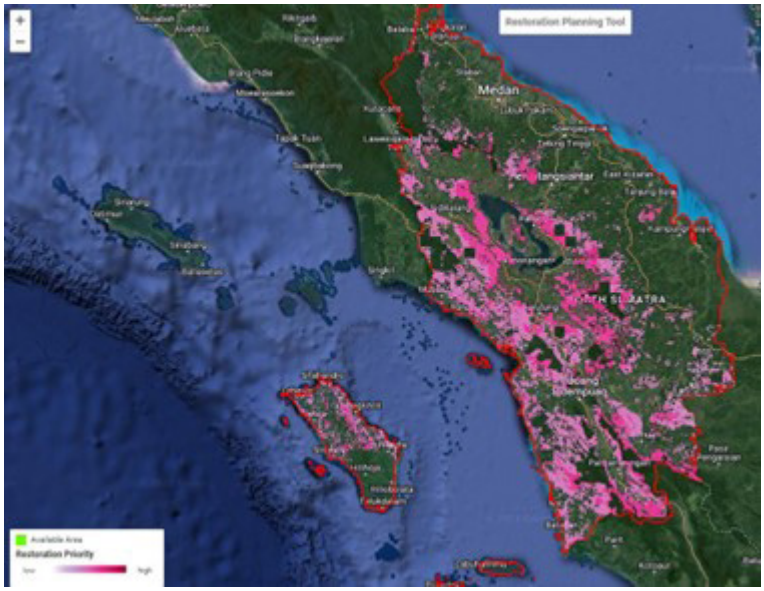
North Sumatra:

Indonesia's North Sumatra Province covers 7.3 million hectares (ha) and is home to more than 14 million people, 41% of whom are employed by the agriculture and forestry sectors. The province has 33 districts and municipalities and 10 of them are coffee production areas. These are Humbang Hasundutan, Dairi, South Tapanuli, Mandailing Natal, Pakpak Bharat, Samosir, North Tapanuli, Toba Samosir, Karo and Simalungun.

Due to continued COVID-19 concerns about in-person meetings in Indonesia, 81 participants from national government, sub-national government, exporter companies, farmer associations, NGOs attended online workshop to discuss action plan activities.

Priority actions determined by participating organization in North Sumatra include:

1. Establish a farmer database to support the decision making and program planning
2. Improve coordination among governments and partners related to coffee productions
3. Create sustainably managed coffee production through improved conservation and GAP practices at least in 20% of farmers in North Sumatra by 2026
4. Ensure financial sustainability of coffee business at farmer level by strengthening the capacity of farmer association (institutional and technical capacities)
5. Address impact of climate change by resolving forest tenurial issue and restoring degraded forests around coffee production areas



Restoration opportunities in coffee & other crops, North Sumatra

Key Learnings:

- In Colombia, local stakeholders were interested in incorporating additional data that is specific for the regions. For example, replace the vegetation cover layer used in the tool with a more up to date one with a higher precision scale for a given region, such as Huila. Other examples: Watershed planning (POMCAS tool), local or regional protected areas. In addition, stakeholders noted that it could be interesting to add other layers of information (i.e., cadaster,

mining activities, etc.) which could complement the analysis by incorporating additional sectors or land uses, making it less specific to coffee. This could enhance the restoration and protection prioritization in the landscape, beyond just coffee areas.

- In Indonesia, feedback on the tool and approach to prioritization was overall positive. Unlike the landscapes in Colombia that are predominantly focused on coffee production, North Sumatra is known for production of other crops in addition to coffee, including palm oil, cocoa, coffee, rubber and timber. To take a true landscape approach, there was support for incorporating information on these other crops into the tool to support landscape dialogue.

3 INTEGRATING LEARNINGS INTO DECISION-MAKING PROCESSES VIA USER-FRIENDLY TOOLS, RESOURCES AND OUTREACH

The main output of the project – the restoration & prioritization tool - has been shared via the Sustainable Coffee Challenge during two webinars where industry and civil society partners were present. The tool has created some buzz already – with the Smithsonian Migratory Bird Center inquiring about the use of the tool for programming in Colombia, as well as questions about methodology and access from several global traders and retailers. In addition to webinars, CI created a landscape landing page on the sustaincoffee.org website and added an overview of the tool and a direct link for users to access it in Google Earth Engine. Resources to accompany the tool – such as a read me, overview of methodology and one pager were also developed and housed on the landing page.

Apart from sharing the tool and other outputs with Challenge partners, CI participated in several conferences where this work was presented to a variety of audiences. A poster about the restoration tool's methodology highlighting Huila, Colombia as a case study was accepted and displayed in the Map Gallery for the 2022 Esri International User Conference held July 11-15 in San Diego, CA. In addition to an opening night reception held in the Gallery for all attendees, the Gallery was strategically placed in a major throughfare between session rooms to ensure maximum visibility for the maps and posters. This year's conference was attended by nearly 15,000 people from around the world and across sectors and industries. The poster went on to win First Place in the Map Gallery's Analytic Methods and Results category. The poster was later presented in the Map Gallery of the North American Cartographic Information Society Annual Meeting held in Minneapolis, Minnesota October 19-22 where there was a great focus on data visualization techniques.

Key Learnings:

- Since the launch of the project back in 2018, there have been several changes in the coffee sector. First, there has been an increase in corporate commitments to net zero emissions (or beyond) which has increased the interest in the role of nature in achieving those goals. In addition, legislation related to "imported deforestation" that has been in discussions in Europe for several years, progressed. Both pressures have created an expansion of interest in the work underway. While the use case for the

products developed differs slightly from what would be needed to respond to due diligence legislation or reach a climate target, the work lays the foundation for additional analysis. The urgency around compliance, for example, has piqued the interest of traders who recognize that without a clear understanding of coffee productive areas, it will be difficult to ascertain claims about zero deforestation at scale.

ADDITIONAL EFFORTS

In addition to the initial scope funding by the Walmart Foundation, within the last six months of the project, CI was able to expand efforts to include support for complementary activities that the team has been leading with sector and not-for profit partners.

Leveraging Artificial Intelligence to create a coffee layer

Building from the work conducted by CIAT and learnings, CI partnered with a technology partner (Google) and satellite imagery provider (Planet) with the intention of developing and applying machine learning algorithms to high resolution imagery, at scale, to generate a global coffee layer and/or on-demand boundaries of coffee areas. CI is currently building a large training dataset that includes both data collected in the field and digitally ocular sampled polygons over recent high-resolution imagery. The algorithm developed for identifying coffee trees on the landscape will be rigorously validated both for the year it was trained from and additional years, potentially allowing the algorithm to be applied to future imagery as tasked. A core set of partners including CI, leading coffee companies, Planet and a technology partner will collaborate to build a first solution set for Colombia, Peru & Ecuador.

In the final months of 2022, Walmart Foundation supported CI staff time spent on digitization efforts, as well as private sector outreach to collect additional validation data. While the project is ambitious and the team is still unsure if an algorithm can be created to generate a coffee layer with high level of confidence, in recent months, a roaster and two traders have expressed interest and are joining in as a data contributor and thought partner.

Increasing knowledge of tree species used in and around coffee areas: Shade Catalog Peru

As part of Conservation International's collaboration with World Coffee Research (WCR) and the Smithsonian Migratory Bird Center (SMBC) a 'Shade Tree Catalog' for coffee landscapes was produced for Peru. This is the second volume in the series of Shade Catalogs, the initial focused on Indonesia and was launched in 2020. The intention is that additional country volumes will be created in the future and housed on the shadecoffee.org website.

The catalog is intended to promote the diversity of shade trees within coffee farming systems with applications for any group propagating shade trees or providing trainings about the importance of shade trees as a component of sustainable coffee management. In total, 138 species were characterized for Peru. The farmer and agronomist focused catalog accompanies WCR's Coffee Variety Catalog and provides guidance on tree species that have both economic and environmental benefits. When moving from planning to action, as suggested in this project, understanding tree species that work well in or around coffee areas is critical to promote restoration with farmers. While the focus on this edition was not Colombia, the Peru catalog collates species found in the Andean region.

Walmart Foundation support enabled our organization to move the species content created by SMBC to an online platform. The digital version of this catalog has been developed for Peru and is hosted on Shade Catalog | Home (shadecoffee.org).

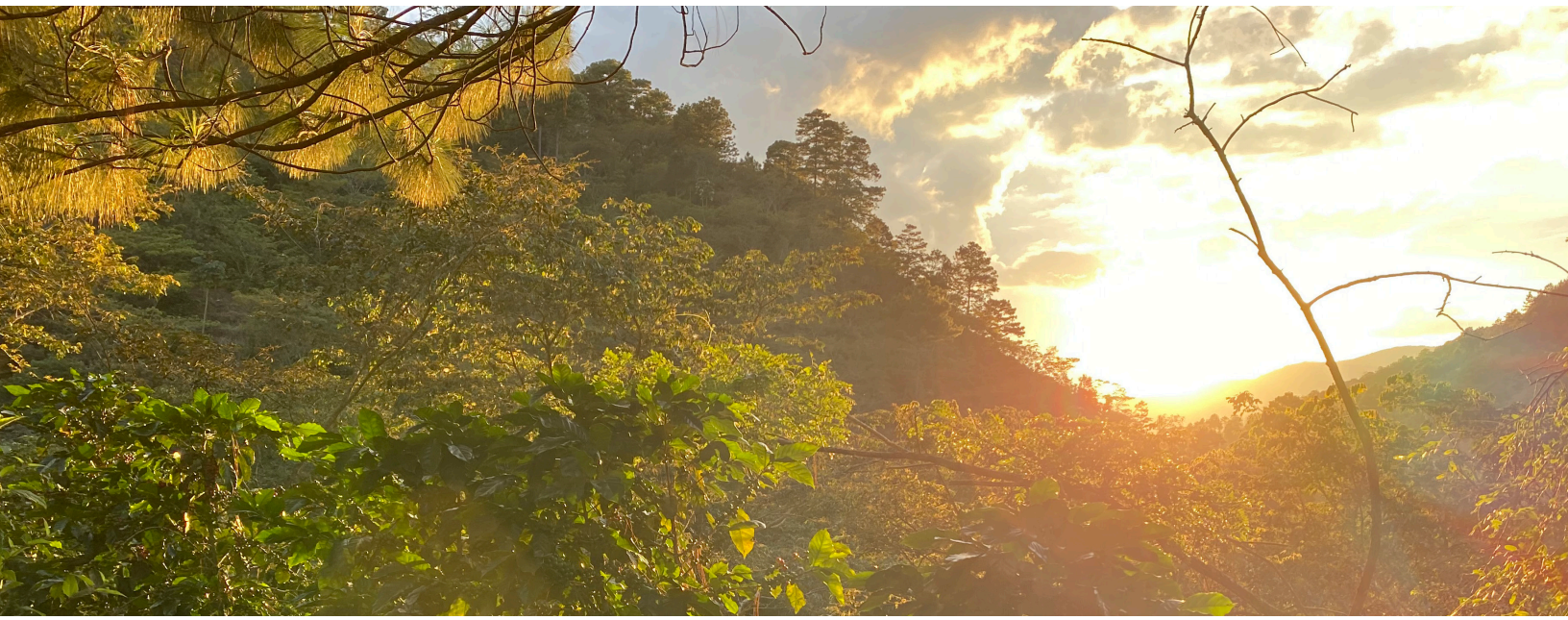
Recommendations:

- **Data quality and characteristics:** Improved collection and validation of data from a variety of coffee systems is critical to enable decisionmakers with a more robust understanding of coffee growing. CI recommends that all actors in coffee supply chains urge the collection of more and finer scale data beyond the provincial/jurisdictional level on coffee areas. in addition to correct locational data, data on production systems (ie: sun, shade, etc) and supplementary information on proximity to forest, other crops in the region, etc would allow for more detailed, accurate, easily accessible mapping of coffee production with less reliance on time-consuming human validation exercises.

- **Data sharing:** Building on the insights from CIAT's work in developing a coffee map, Conservation international has turned to members of the Sustainable Coffee Challenge to promote data sharing, in an anonymized format. While it is understood that companies are unwilling to share supply chain data that could be considered competitive in nature, the idea of anonymized data sharing with the purpose of enabling more advanced research, informed decision making and planning, and ultimately, creating public goods that support everyone in coffee is something that CI is promoting. For example, data could potentially be used to scale the creation of a coffee data layer using artificial intelligence.

- **Scaling up the prioritization too to new geographies:** If there is interest to scale the restoration & prioritization tool, given that the structure of the tool has been created there are opportunities to do so. However, the main constraint will be the availability of localized data. Therefore, in order to scale to additional countries, decision on the data sets used (ie: local data vs global layers) will be key.

- **Moving from prioritization to action in Colombia & Huila:** CI should leverage multi-stakeholder networks to continue to drive alignment and subsequently, investment in the prioritized regions and actions laid out by stakeholders in Huila, Antioquia and North Sumatra. This can be done through the Sustainable Coffee Challenge, as well as the Coalition for Sustainable Livelihoods (CSL) in Indonesia. Additionally, in reference to Indonesia, CSL, which has traditionally been more focused on palm oil, can easily incorporate the recommendations developed as part of this project to bring in more actors from the coffee industry and strengthen efforts in the landscape.



Disclaimer: The research included in this report was made possible through funding by Walmart Foundation. The findings, conclusion and recommendations presented in this report are those of Conservation International alone, and do not necessarily reflect the opinions of Walmart Foundation.