APPENDIX 5: PILOT 2: CAFÉ SELVA NORTE

1.Executive summary

As part of the "Land Degradation Neutrality Fund (LDNF) Impact Monitoring Methodology" developed by Conservation International and OpenGeoHub two pilot studies were completed. This document presents the pilot study for the Café Selva Norte, a sustainable coffee production project in Northern Peru, part of the Urapi Sustainable Land Use programme, managed and operated by Ecotierra. The pilot includes project baseline for the three LDN indicators, changes in land cover, land productivity and soil organic Carbon, which also includes recommendations on how to monitor the indicators over the project lifespan, and an appendix presenting an assessment of potential impact of project activities on the three LDN indicators which is intended to inform the implementation of the monitoring plan.

The Café Selva Norte LDN baseline found that:

- Land productivity: 4.1 % of the investment area is currently identified as degraded compared to 4.8 % within the larger investment landscape
- Land cover: 86.3 % of the investment area, within the representative area assessed, is currently covered by woody vegetation (55.0 % tree covered and 31.3 % shrubland) as compared to 78.0 % in the investment landscape (47.1 % tree covered and 30.9 % shrubland).
- Soil organic carbon: Baseline SOC content within the first 30 cm of the soil was 109.7 tons C/ha in fallow sites, 97.9 tons C/ha in sun grown coffee, and 103.3 tons C/ha in shade grown coffee.

The proposed monitoring plan following the LDNF Impact Monitoring Methodology is:

- Land productivity: Wall to wall annual assessment using remote sensing data
- Land cover: Every 4 years repeated measures of land cover change within the same representative area used for baseline and using very high spatial resolution data. If wall to wall 30 m resolution products can be obtained or produced for the full investment landscape, those could completement the results obtained from the very high-resolution data.
- Soil organic carbon: Initial and final SOC measurements with in the same representative area used for the baseline and following the same cluster design. Annually, coffee production measures can be used to assess changes in productive capacity of the soil and impact of ongoing agricultural practices.

Based on the feedback from Ecotierra, it is important to notice the multiple activities are being implemented in the investment area, some intended to avoid, others to reduce, and others to reverse land degradation. Since the impact of each of those typologies of on the ground activities will be differently captured by the three indicators, it is suggested that the monitoring plan captures changes in land cover, productivity and SOC differently for those three types of activities.

2.Café Selva Norte Project[11]

The Café Selva Norte (CSN) project is located in the Amazonas and Cajamarca regions in north of Peru, with a total potential area of thousands of hectares. The Project area includes a set of dispersed coffee producers' properties in the mountainous region know and "*selva alta*" where coffee is mainly produced between 1200 and 1800 meters above sea level. The project area is one of the three main coffee production zones in Peru and is recognized for the quality of its production.

The project aims to meet its goals through a holistic approach including 3 components

1. Land use transition to:
   - Recover degraded lands with productive agroforestry systems,
   - Rehabilitate old, fragile agroforestry systems increasing their productive lifespan and therefore avoiding deforestation risk,
   - Protect remaining forest and stop slash and burn practices,
   - Reforest with a mix of timber species for sustainable logging in the future.
2. Value chain consolidation by:
   - Building infrastructure to strengthen co-op production capacity and positioning,
   - Creating and strengthening capacity,
   - Developing marketing tools and positioning products into specialty markets,

1.Revenue diversification through climate finance and strong monitoring systems using the Shade Coffee & Cocoa Reforestation Carbon Project (SCCRP) as a platform to:
   - Generate new revenue flows based on payment for environmental services (reforestation & forest protection),
   - Generate a robust set of key performance indicators to strengthen sales and obtain added value.

3.Defining the area of interest

The CSN project, managed by the Ecotierra, includes to date with 340 small coffee farmers located in the Amazonas and Cajamarca regions of northern Peru. Each of those 340 farmers represent an **investment site** (mean =1.10 ha, median = 0.98 ha, standard deviation = 1.04 ha), as defined in the LDNF Impact Monitoring Methodology. The aggregation of all those sites

[11] Verbatim from: Ecotierra. 2017. Café Selva Norte Peru project, Canopy project pipeline. https://www.cafeselvanorte.com/

represent the full area of direct intervention the project will have in the region, referred to as the **investment area**. To better understand the context in which these activities will take place, and to compare the baseline conditions of the investment area to similar areas in the surrounding region, an investment landscape was defined for this project. Considering the highly heterogenous conditions of this mountainous region, we defined the **investment landscape** for this project as all land within a 2 km buffer of the investment area (801,0 km^2, Figure 1).

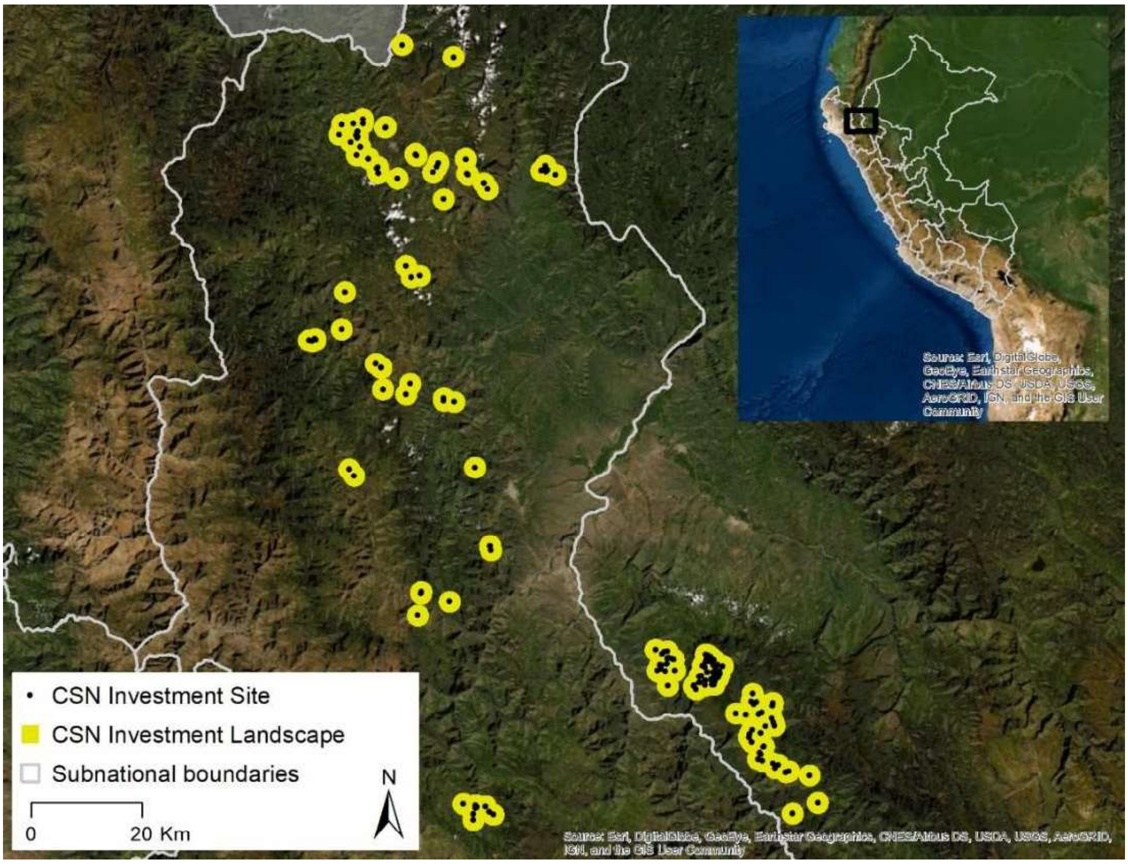

Figure 1: Café Selva Norte Project in Northern Peru is comprised of 340 individual investment sites (black dots on the map). The investment area is the aggregate of all those 340 sites. The investment landscape, in this case, has been defined as the area within a 2 km buffer around the investment area.

4.The LDNF CSN project baseline

Projects part of the LDNF portfolio need to determine baseline conditions for each of the three indicators of land degradation (changes in primary productivity, land cover, and soil organic C), and monitor progress through the project lifespan. The LDNF Impact Monitoring Methodology provides guidance on how to complete baselines and set up the monitoring framework. In the sections below we present the baselines for the CSN project broken up by indicator.

4.1.Land productivity

Land productivity is the biological productive capacity of the land, the source of all food, fiber and fuel that sustains humans. Following the LDNF Impact Monitoring Methodology, it is recommended that the normalized difference vegetation index (NDVI) be used as an indicator of productivity, as it is well-correlated with actual changes in productivity based on measurement on the ground, and as there is a long-term record available to allow comparison of changes in NDVI in a particular year with how NDVI has changed in the past. Given the combination of small median investment area size (0.98 ha) and large investment landscape (801,0 km^2), the recommended datasets for monitoring productivity would be at a resolution of ~30 m. However, presently only 250 m products are available for time series analysis as the ones needed for assessing productivity. For that reason, we computed productivity baselines using MODIS 250 m resolution data processed as recommended in the LDNF Impact Monitoring Methodology. For this baseline, we used Trends.Earth to compute the 5-class productivity indicator for the recommended most recent 15-year period 2005-2019 (Figure 2). The 5-class productivity integrates three sub indicators: trajectory, performance, and state.

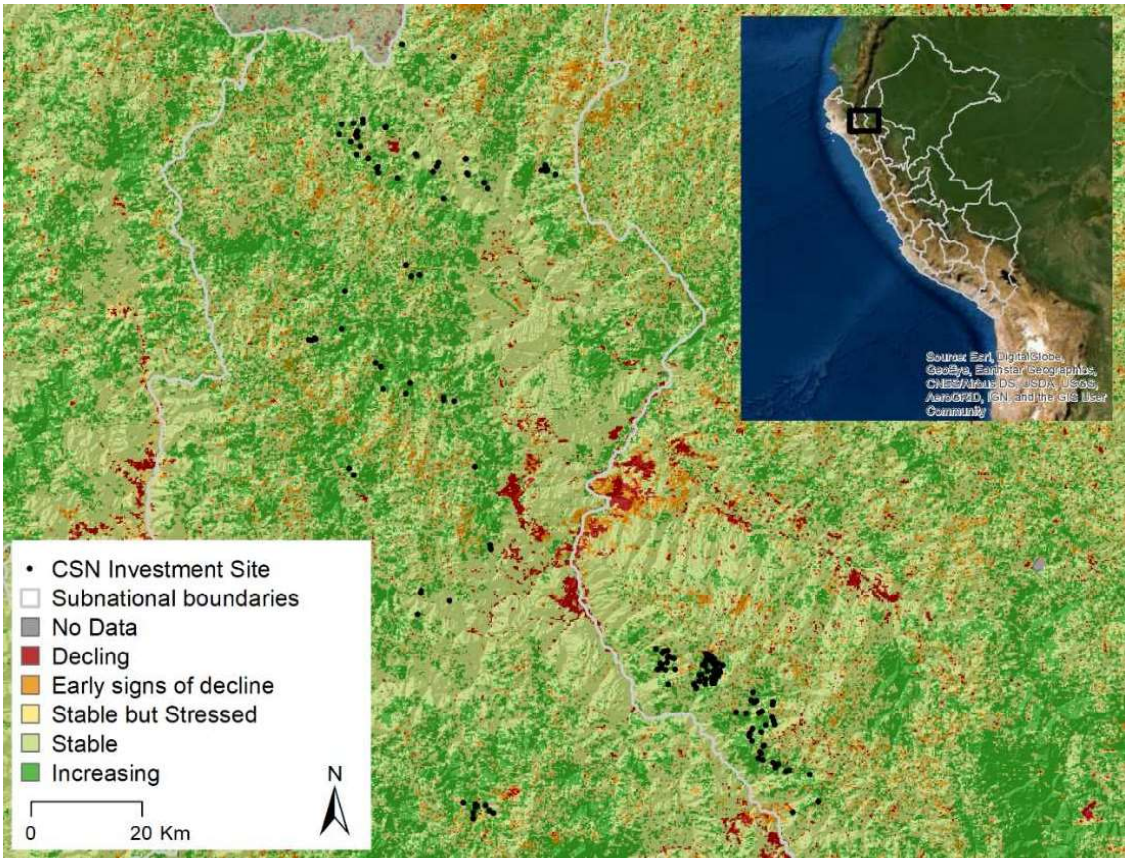

Figure 2: Productivity baseline map for the Café Selva Norte investments in Northern Peru.

Overall, the investment area presents a baseline productivity degradation level of 4.1 %, compared to 4.8 % degradation during the 2005-2019 period for the broader investment landscape. (table 1).

Productivity class	Investment Area	Investment Landscape
Declining	0.6 %	0.6 %
Early signs of decline	3.5 %	4.2 %
Stable but stressed	0.0 %	0.0 %
Stable	44.7 %	53.1 %
Increasing	51.2 %	42.1 %
% Degraded	**4.1 %**	**4.8 %**

Table 1: Productivity baseline for the Café Selva Norte Investment Area and Landscape computed for the period 2005-2019.

Monitoring recommendations for land productivity

Of the three LDN indicators, productivity if the most responsive to changes in land management and cover and any other condition which affects the productivity of the vegetative cover. For that reason, land productivity should be monitored annually to the LDNF following guidance from the LDNF Impact Monitoring Methodology. Through annual assessments of changes in land productivity, Ecotierra and the LDNF will be able to monitor the impact of the investments on land degradation and adapt accordingly in order to maximize the contributions of the project towards LDN locally and at the national scale.

4.2.Land cover

Through the assessment of changes in land cover, major transitions in system structure and configuration can be monitored over time. It is critical to use a land cover product which aligns with the size and spatial distribution of the interventions being monitored, to have confidence in the reliability and usefulness of the results. In the case of CSN project, the combination of small investment sites (0.98 ha) and large investment landscape (801,0 km^2), a combination of regional maps at 30 m resolution with focus areas using very high spatial resolution data would offer the best approach.

For this baseline we evaluated the national vegetation cover map from 2015 (Mapa Nacional de Cobertura Vegetal del Peru, 2015). However, two main characteristics of such dataset deemed it not suitable for this baseline: 1) Date mismatch: The land cover map published in 2015 was produced with satellite images from 2011. Nine years is too large of a time gap for that dataset to be useful for this baseline, and 2) Minimum mapping unit of 16 ha (>16 times larger than the median investment site area) The production of a very high spatial resolution land cover map for a representative subset area was decided.

To develop the baseline for the land cover LDN indicator, a multispectral very high spatial resolution for the study area was acquired (SPOT 1.5 m resolution for November 2019). The area was selected for the following reasons: 1) it has the larger concentration of farmers, 3) it was the area visited in the field in December 2019, and 3) it is the same area in which SOC baseline was produced with field data. The area of this land cover map represents 20.3 % of the investment landscape (figure 3). Using an object-based classification approach a land cover map with four classes was produced: tree, shrub, grass, and built-up (overall accuracy = 77.5%, Figure 3). The grassland class includes grasslands and herbaceous covers such as annual crops.

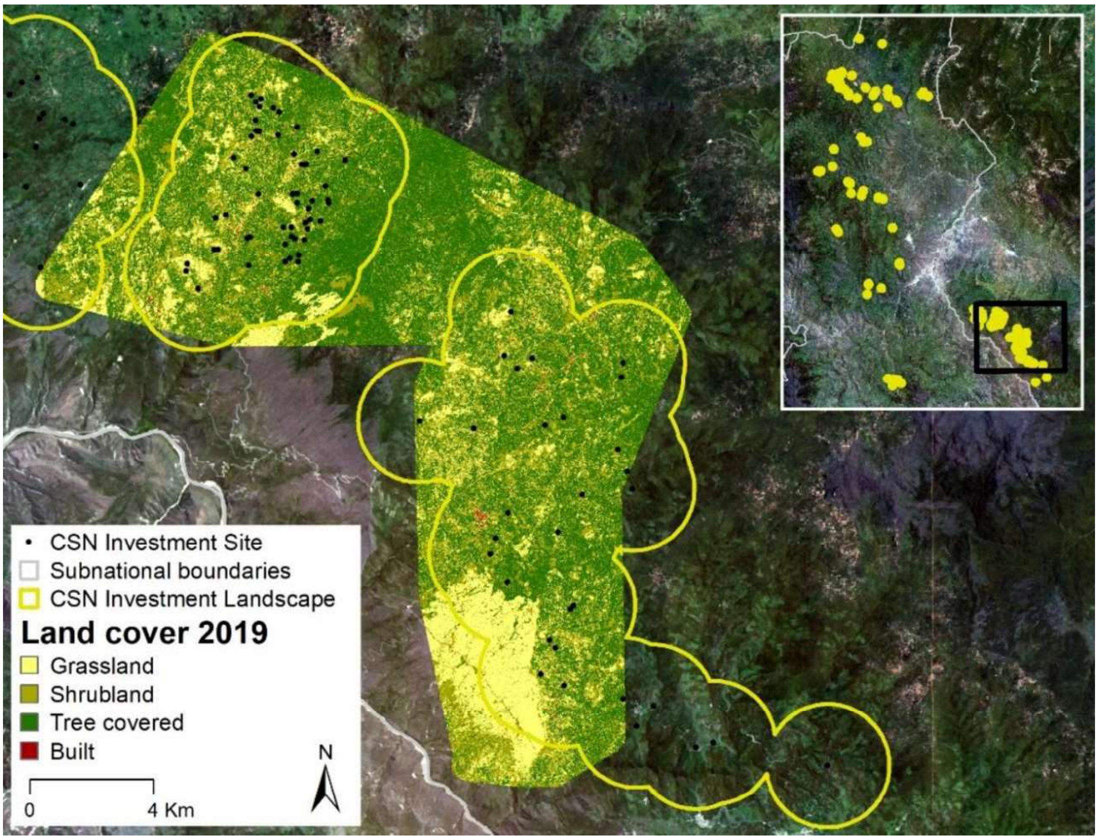

Figure 3: Land cover baseline map for the Café Selva Norte investments in Northern Peru.

The baseline land cover distribution for the assessed area shows a dominance of tree covered classes both in the investment area and the investment landscape, although higher in the investment area (55% vs 47%). Tree covered classes include both shade-grown coffee and natural forests in the region. Approximately 30% of the areas are covered by shrublands.

Shrublands in this assessment include sun-grown coffee and some intermediate stages of land abandonment and natural regeneration, with relatively low woody vegetation.

Land cover	**Investment Area**	**Investment Landscape**
Tree covered	55.0 %	47.1 %
Shrubland	31.3 %	30.9 %
Grassland & crops	11.3 %	21.6 %
Wetland	0 %	0 %
Artificial	2.5 %	0.5 %
Bare	0.0 %	0.0 %
Water body	0.0 %	0.0 %

Monitoring recommendations for land cover

Changes in land cover tend to be slower than changes in primary productivity, for that reason, land cover is expected to be monitored and reported to the LDNF every 4 years at minimum. For consistency, it is recommended that changes in land cover are monitored for the same sample area as used in this baseline and using land cover maps of similar spatial resolution (1.5 m pixel size) and class scheme. If during the project lifespan, 30 m resolution products appropriate for monitoring changes in land cover of this type of interventions became available, monitoring wall to wall would be recommended as a complementary measure.

4.3.Soil Organic Carbon

Monitoring change in soil carbon due to project interventions requires the project proponent to consider several different decision points related to SOC and overall LDN project achievement. Recent guidance prepared by the Science-Policy Interface of the UNCCD can be applied to project descriptions to obtain guidance regarding investment into SOC assessment for LDN. The LDNF Impact Monitoring Methodology provides guidance on how to determine the appropriate monitoring in indicator depending on project objectives. Ecotierra defines the Café Selva Norte project as an agroforestry type of intervention. Agroforestry projects in the context of LDN are required to monitor SOC, through a combination of initial and final SOC assessments (either through field data collection or modeling) with production statistics as intermediate proxy variables for soil condition.

For this baseline, following guidance from Ecotierra, the baseline sample area was identified in the southern region of the investment landscape. This area representing 20.3 % of the investment landscape has the larger concentration of farmers providing logistics, financial, and methodological advantages. During December 2019, fieldwork was completed in the southern section of the project area (Figure 4). The main objective of the field work was to collect soil samples to produce the SOC baseline. Given the scale of the project and the significant landscape heterogeneity encompassed by that (due to the mountainous relief and quickly changing aspect), a clustered sampling design was implemented. Each cluster was defined in this case as a combination of a sun grown coffee plot, a shade grown coffee plot, and a fallow site in close proximity, minimizing the variability in environmental factors which could contribute to the differences found in the response variables. Such a sampling design allows for achieving two main objectives: 1) completing the baseline SOC assessment (presented in this section), and 2) Applying a space-for-time substitution, to increase our understanding on the potential impact of the proposed interventions in SOC (presented in section 5).

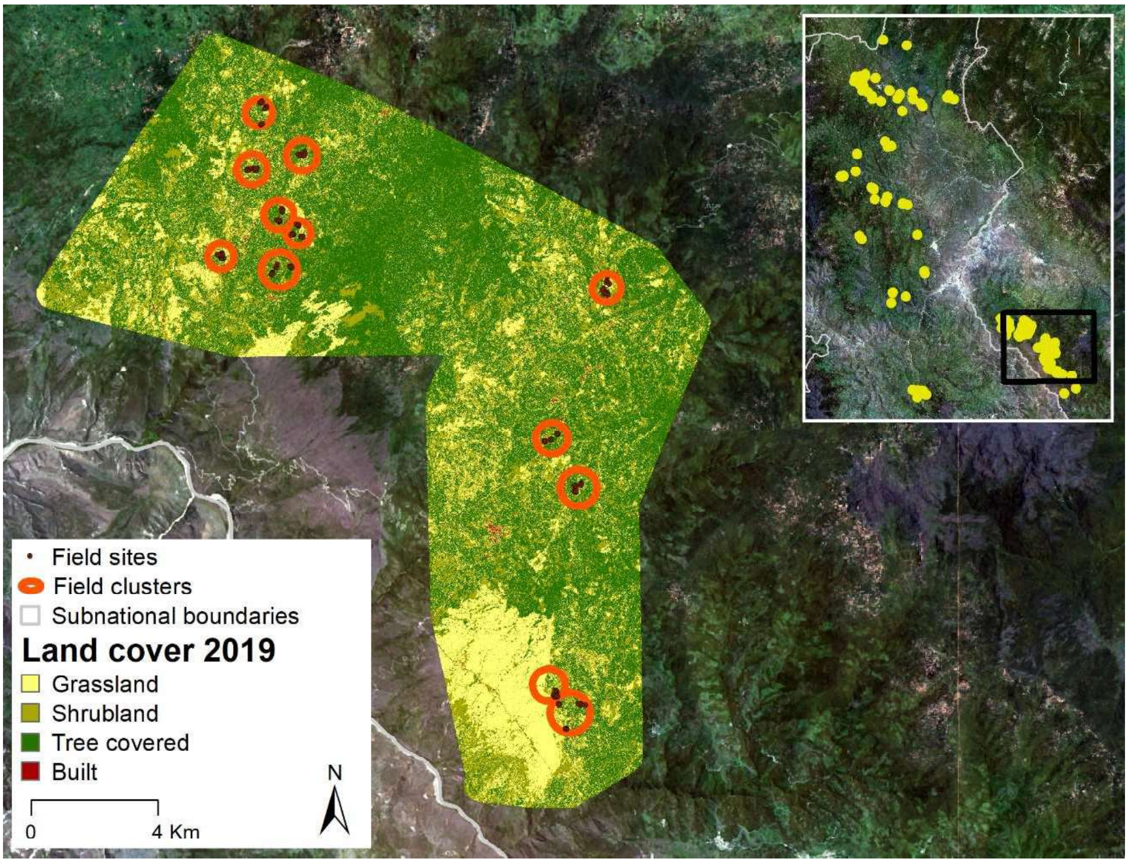

Figure 4: Sampling design for the soil organic carbon baseline for the Café Selva Norte investments in Northern Peru.

Following the cluster design, soil samples to 30 cm depth were collected in fallow sites, sun grown coffee and shade grown coffee farms. Soil samples were collected with an auger to determine organic C concentration and sample weight (back calculating bulk density) to obtain SOC stock estimations (see field guide for details on data collection). Soil samples were processed at the local soil lab in the city of Jaen, Peru. A total of 12 clusters were surveyed, collecting 137 soil samples, 46 in fallow sites, 45 in sun grown coffee farms, and 46 in shade grown coffee farms (Figure 5). At each point coordinates were recorded, and an oral history of use was documented (current and before establishment of the current land use, usually based on oral records).

Figure 5. Field work photographs showing typical conditions in a fallow site (top left), sun grown coffee (top right), shade grown coffee (bottom left) and a soil sample (bottom right).

Soils are inherently spatially very variable, and the cluster design tries to minimize that variability to detect the significant differences. A two-way analysis of variance was used to assess the significance on the mean differences between the three interventions and controlling by the variability among clusters. Carbon content is very variable in the region, as can be observed by the high vertical spread in Figure 9. Mean SOC stocks were higher on average in fallow sites (109.7 tons/ha) than on sun grown coffee (97.9 tons/ha) or shade grown coffee (103.3), but differences were not statistically significant (p-value = 0.134).

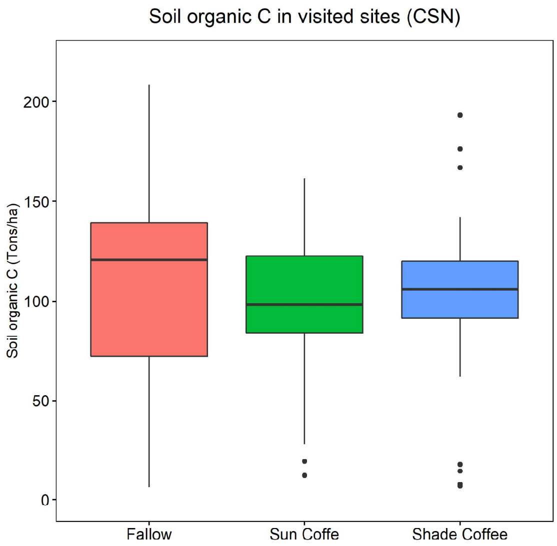

Figure 56. Mean baseline SOC for fallow sites, shade grown coffee and sun grown coffee farms (no significant difference at baseline, p-value = 0.134).

<u>Monitoring recommendations for SOC</u>

Soil organic carbon is, of the three LDN indicators, the most challenging to measure as EO data can only be of assistance, since SOC can not be directly measured from remotely sensed data. SOC is a slow changing variable, meaning that a long period needs to occur in order to detect significant changes in its magnitude after some type of intervention, such as the establishment of an agroforestry system. Moreover, field measurements are logistically challenging and require a significant resource. For that reason, the LDNF Impact Monitoring Methodology requires SOC to be measured (either with field data or modeled), at the beginning and end of the project, and using production measures (e.g. tons of coffee produced per unit and area and time) as an intermediary proxy for understanding the changes in soil health to inform adaptive management measures which could be required in order to achieve LDN objectives.

5.Supplement: 1: Potential contribution to LDN

The cluster design implemented to produce the baseline for soil organic carbon, allowed us to produce some preliminary analysis on the potential contributions of the activities to be implemented as part of the Café Selva Norte project. Analysis presented in this appendix are not required as part of the LDNF Impact Monitoring Methodology, but are recommended, since the insights obtained can be useful at designing a locally relevant monitoring plan.

5.1.Land productivity

To date, MODIS remote sensing data is the only available NDVI product with a time series record dense enough to produce robust land productivity baselines over a 15-year period. However, Landsat and Sentinel harmonized collections are actively being developed, and will be made available to the public within a years' time. This harmonized collection provides the spatial resolution of Landsat and Sentinel products, but with a much higher temporal frequency than each of the original products[12]. Having high spatial and temporal frequency is key for evaluating interventions with a small spatial footprint and which require the evaluation over the course of the year, and not just at one point in time. The Normalized Difference Vegetation Index (NDVI) from a sample Harmonized Landsat and Sentinel surface reflectance product was compute, and the annual integral for the years 2017 and 2018 were derived following SDG 15.3 guidance (Trends.Earth, 2018). Annual NDVI integral values were extracted for the 137 visited locations and analyzed for each year using a two-way analysis of variance[13].

For the assessment of potential impact of CSN interventions on productivity, we used a space-for-time substitution approach, in which we assume that CSN activities will generate a transition from fallow or sun grown coffee to shade grown coffee. Significant differences in primary productivity were found between the conditions assessed, with shade grown coffee presenting higher annual productivity than either fallow or sun grown coffee for the two years analyzed (Figure 77). Based on this results, it can be expected that CSN project will have a positive impact on land productivity, and a change of magnitude enough that the remote sensing products will be able to detect them as part of the monitoring framework.. Continued monitoring is needed to fully assess the impact of these interventions in long term.

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[12] Claverie, M., Ju, J., Masek, J. G., Dungan, J. L., Vermote, E. F., Roger, J.-C., Skakun, S. V., & Justice, C. (2018). The Harmonized Landsat and Sentinel-2 surface reflectance data set. Remote Sensing of Environment, 219, 145-161.

[13] Venables WN, Ripley BD (2002). Modern Applied Statistics with S, Fourth edition. Springer, New York. ISBN 0-387-95457.

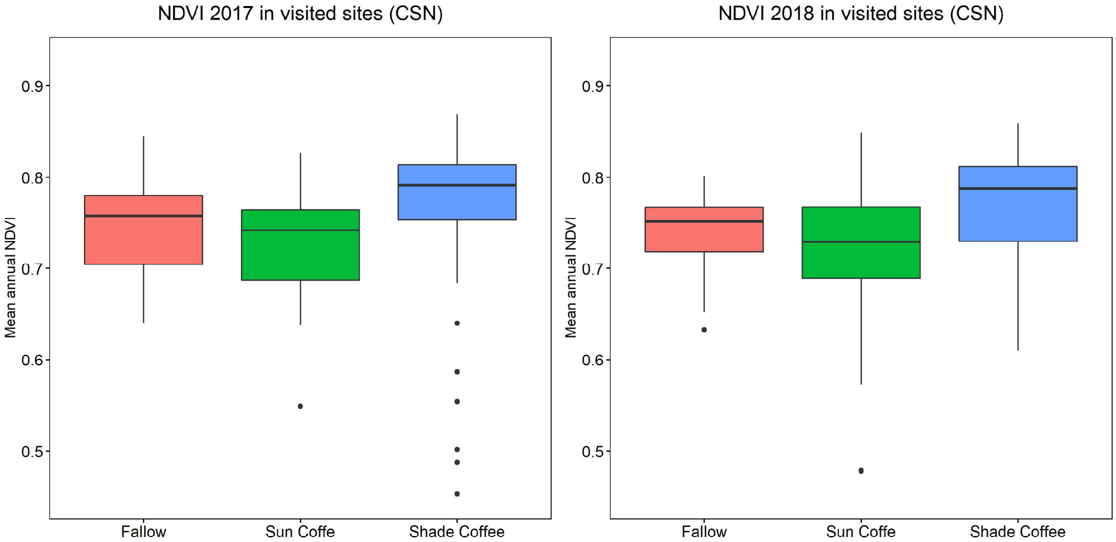

Figure 7. Frequency distribution of annual integrals of NDVI for 2017 and 2018 comparing fallow sites, sun grown coffee and shade grown coffee. Significant differences were found between shade grown coffee and the other treatments for both years (p-value < 0.01 in both cases)

<u>5.2.Land cover</u>

To evaluate the potential effect of CSN's proposed interventions in the land cover indicator, we used the same space for time substitution approach, and the same high spatial resolution land cover map produced for the baseline derived from SPOT 1.5 m resolution imagery for November 2019. Since one of the main activities of CSN will be gradually convert them to coffee plantations, first sun grown, and later shade grown as the canopy closes; we assessed the differences in land cover among the different types of farm, and we identified a potentially positive impact on the land cover LDN indicator (Figure 8). Keep in mind that of the three LDN indicators, land cover is the only one in which local conditions and specific objectives inform the interpretation of which changes constitute improvement and which one degradation. In the context of an agroforestry project with the objective of restore degraded lands, we consider increase in tree cover as contributing towards LDN. Results show that grass cover gradually reduces from fallow sites to shade grown coffee areas, as tree cover increases from 25% to over 70%. These results would suggest a positive impact of this intervention on the land cover indicator. It is important to notice that CSN will also focus on avoiding that shade coffee goes back to fallow or that forest goes to full sun coffee, reinforcing the importance of a continuous land cover monitoring system (every 4 years), in which results land cover change results are disaggregated based on the main objective of activities happening in each site.

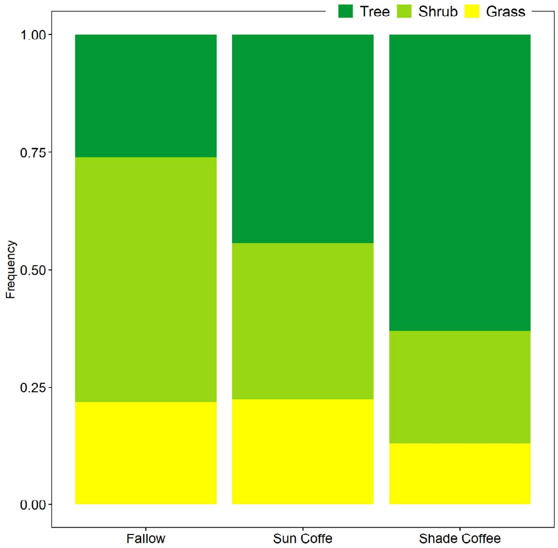

Figure 8. Land cover baseline condition for CSN project farms in 2019. Tree cover increases as sites are converted from fallow to sun grown coffee and shade grown coffee.

5.3.Soil organic carbon

The analysis completed for the SOC baseline section, can be interpreted as a reference condition to which to compare progress over time, but they also serve to understand potential changes now of future interventions using a space for time substitution approach. Soil samples were collected using a cluster design to minimize variability in soil conditions among the three type of treatments evaluated within clusters. This design allows us to have an initial understanding on the potential impact of changes in management in SOC as part of the CSN project. A two-way analysis of variance was used to assess the significance on the mean differences between the three interventions evaluated and controlling by the variability among clusters. Carbon content is very variable in the region, as can be observed by the high vertical spread in Figure 9. Mean SOC stocks were higher on average in fallow sites (109.7 tons/ha) than on sun grown coffee (97.9 tons/ha) or shade grown coffee (103.3), but differences were not statistically significant (p-value = 0.134). These results would indicate that the potential impact of the CSN project on SOC would be not significantly different, unless the drivers of the SOC distribution in the fallow case are understood and targeted (e.g. preferentially selecting low SOC fallow sites for development and avoiding high SOC fallow sites).

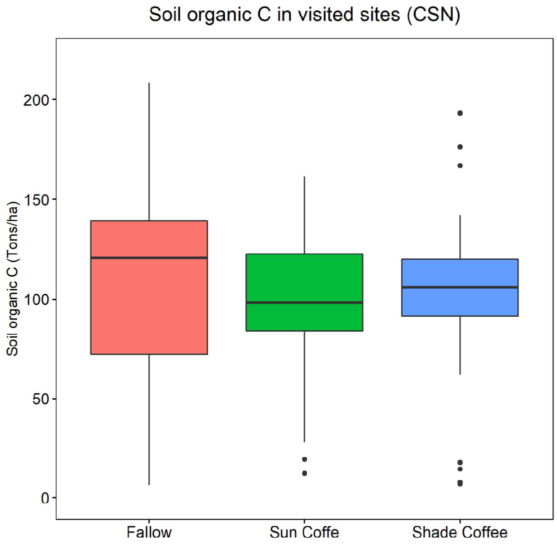

Figure 9. Mean SOC was not significantly different between fallow sites, shade grown coffee and sun grown coffee farms (p-value = 0.134).