Agroforestry Expansion in the Peruvian Amazon

Web Tool User Guide and Technical Details

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Center for Biodiversity Outcomes
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Amazon Business Alliance

About this tool

Agriculture is critically important to humanity, but agricultural expansion negatively impacts biodiversity[1]. In Peru, 56% of forest land lost between 2000-2018 was in areas designated for agriculture[2]. To balance these needs, the Peruvian government is promoting the expansion of sustainable agriculture practices, including agroforestry[3]. Agroforestry combines conventional agricultural crops with woody, perennial species to create mixed land-use systems[4] so that timber, fruit, or bark can be produced at the same time as more traditional agricultural crops. Agroforestry systems diversify producer sources of income and can often be more profitable. Agroforestry also benefits biodiversity by providing habitat for wildlife species within the agricultural landscape[5], increasing the ecosystem services provided by the system[6], and enhancing local biodiversity—especially bird species.

Despite these benefits, conversion to agroforestry can be costly for the landholder. Programs to incentivize sustainable agroforestry expansion in the Peruvian Amazon are being considered by the Amazon Business Alliance, an initiative led by Conservation International with funding from the United States Agency for International Development (USAID). However, these programs need to be targeted to the regions where they can achieve the best outcomes for both people and nature.

The Center for Biodiversity Outcomes at Arizona State University developed this tool to assist the Amazon Business Alliance in identifying regions in San Martín and Ucayali where supporting investment in conversion of conventional agricultural practices into agroforestry could have the highest levels of expected Red Listed bird conservation improvements. It allows a user to map and explore the costs and benefits of conversion to agroforestry within or across different provinces for user selected scenarios of optimization goals, and to identify regions that are expected to provide optimal returns from investment. By supporting informed decisions that balance economic development with biodiversity conservation, this tool aims to contribute to a more sustainable and resilient future for the Peruvian Amazon and its inhabitants.

Access the tool here

References

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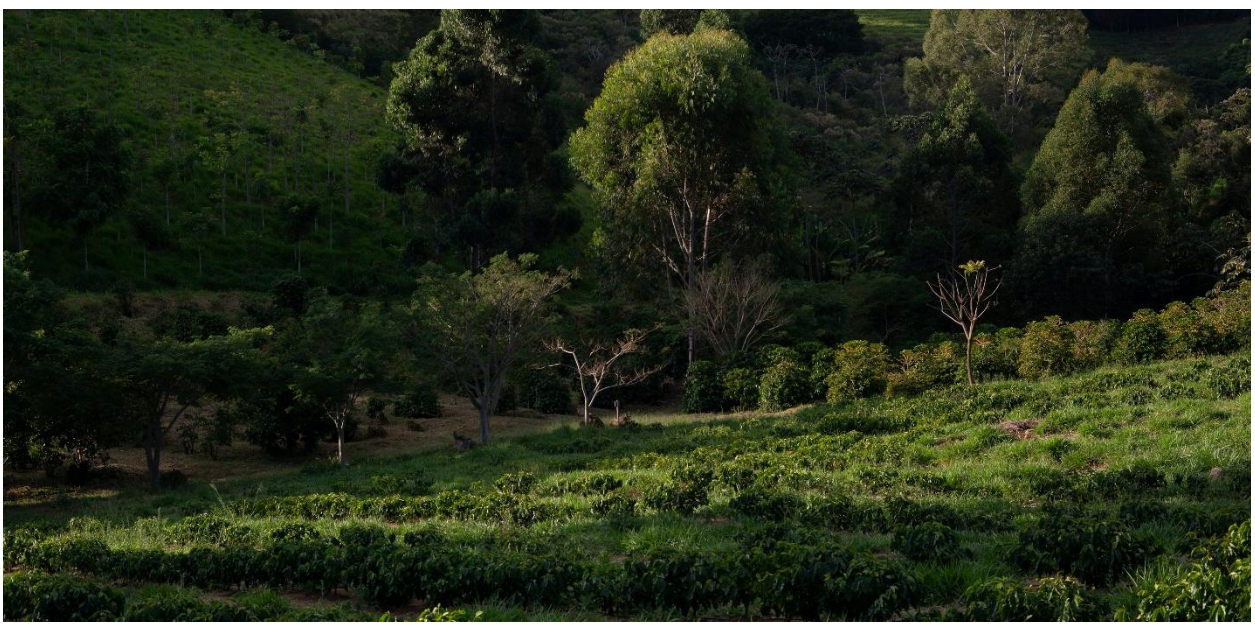


User Guide

This web interface tool allows users to explore the costs and benefits of agroforestry conversion through an optimization lens. The map can be used to guide decision-making about where to invest in agroforestry.

How to use the tool:

1. Open the tool interface to view the initial map of the Ucayali and San Martín regions of Perú.

2. Familiarize yourself with the available layers, encompassed within a Boundary layer that indicates the provinces and districts:

   - Boundary layer: Selection of this layer highlights provinces and districts in the Ucayali and San Martín regions.

   - Cost layer: Displays geospatial data related to the expected cost of transition to agroforestry. This is calculated as the difference between the loss of traditional crop income over a time period and the expected increase in returns from agroforestry during that same period. Higher costs are represented with a lighter yellow color, and lower costs are represented by a deep purple color. The gradient is displayed in the box to the right of the map. The area of a pixel is equivalent to around 87 hectares.

   - Red list species density layer: Represents the density of red listed bird species. The darker color correlates to a higher density of Red Listed species in those specified areas.

   - Optimization STAR-AG layer: expand for multiple budget selection options. This selection highlights areas within the boundary that maximize improvements in conservation status for all Red Listed bird species in the region.

   - Optimization STAR-RARE layer: expand for multiple budget selection options. This selection highlights areas within the boundary that maximizes the benefits for Red Listed Bird species that are directly and severely impacted by current agricultural methods.

- Optimization-ROI layer: With a $10 million budget, this selection highlights areas within the boundary that maximizes the expected benefits in terms of species protection and habitat preservation in correlation with the expected costs of these efforts.

- Optimization-SpecRich layer: With a $10 million budget, this selection highlights areas within the boundary that would maximize the diversity of species within the selected region if transitioned to agroforestry.

- For the optimization layers, the area of a pixel is around 722 hectares.

3. Selecting Areas:

- Selection of the boundary layer highlights both the San Martín and Ucayali regions.

- Search for specific provinces or districts using the search bar on the lower left area of the screen, beneath the subheading titled “District, Province”.

- Each selected district will be highlighted. There is no limit to how many districts can be selected.

- District selection is also possible by clicking on the district outline directly on the map, but this method selects only one district at a time.

- The map will zoom to center on selected districts, and information will appear describing the location and its size.

4. Comparing Districts:

- Select multiple districts in the “District, Province” table to compare their potential impacts.

- The data table in the lower center of the screen will update automatically to reflect your selections as rows. Select the data to be analyzed from the drop-down feature in the top left corner of the data table to summarize different values and analyses. The options are as follows:

    I. Cost: This feature examines the total calculated cost of implementing agroforestry into the selected district areas, both in Sum in millions of USD, and the Average Cost per ~ 85 HA Pixel in USD.

II. Optimization Layers: Depending on the preferred optimization and budget, select an option to numerically display the Percent of District Selected that would benefit from Agroforestry transitions, as well as the Number of Selected Sites it would apply to for each district.

- The light gray box located on the bottom right takes you to the "Graphs" section of the webpage, displaying bar graphs that compare the data for the selected districts.

- Navigate the various optimization level graphs by referencing the columns.

- View the specific statistics for the data table and graphs by clicking the box with four dots, located in the top right corner of each individual graph selection.

5. Interpreting Results:

- The data table summarizes the chosen province, district, and resulting metric calculations based on selection from the drop-down menu relating to cost or optimization values.

- The bar graphs display the percentage of selected districts and the number of selected sites that fall under the chosen layer characteristics. STAR-RARE and STAR-AG have various tables based on budget levels.

Example Scenario

Let's say you have selected the following options:

- **Districts to consider**: Bajo Biavo and San Martin
- **Layer of interest**: Cost
- **Graphs Section**: Optimization-ROI with a $10 million budget

All values can be interpreted in the data table or graphically.

Data Table Interpretation

- **Selected Districts**: The table will list results for Bajo Biavo and San Martin in the rows.
- **Cost Analysis**: Be sure to select the Cost option in the drop down if not already selected.
  - Sum in millions of USD: Displays the total cost of implementing agroforestry in each district.
  - Average Cost per Pixel in USD: Shows the average cost per ~85 HA unit of area.

For example, Bajo Biavo has a total cost of $142.63 million and an average cost per pixel of $132,926.56, while San Martin has a total cost of $62.61 million and an average cost per pixel of $108,315.78.

Image 1: Cost values with both the cost layer and optimization (ROI) layers selected.

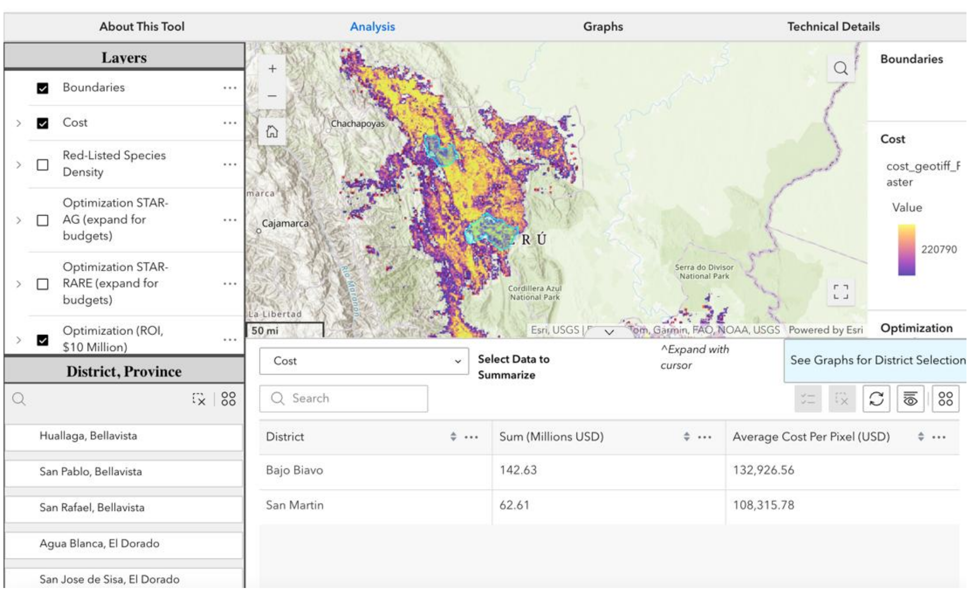
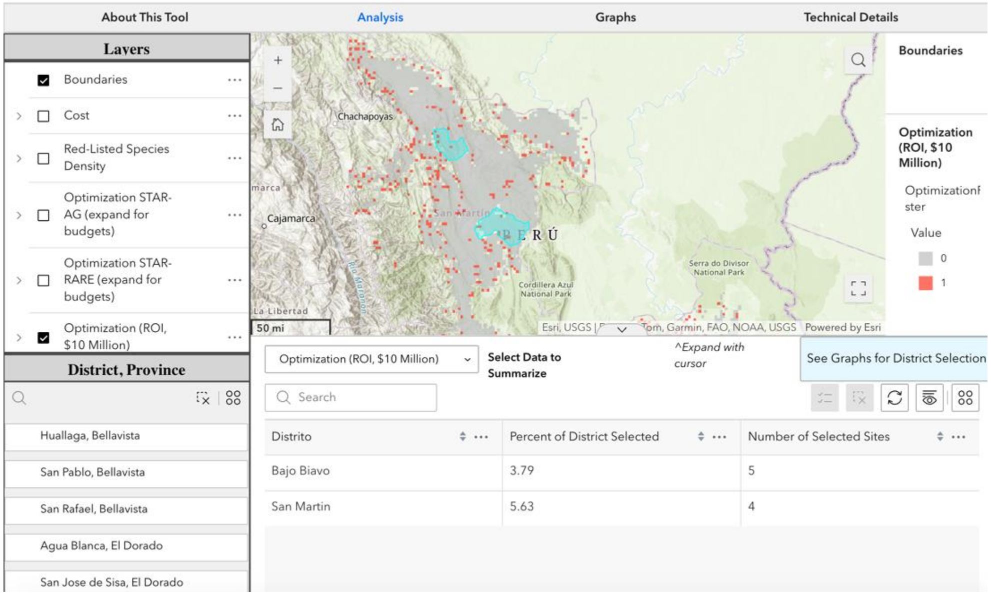


Image 2: ROI values of selected districts with just the optimization (ROI) layer selected.



Graph Interpretation

- **Optimization-ROI Graph**:
  - **Percent of District Selected**: Indicates the proportion of each district that would benefit from agroforestry under the $10 million budget.
  - **Number of Selected Sites**: Shows the number of specific sites within each district that are optimal for agroforestry. These correspond with the red squares on the map.

For example, the graph shows that 3.79% of Bajo Biavo and 5.63% of San Martin are selected, with 5 sites in Bajo Biavo and 4 in San Martin. You can assess which district offers better returns on investment in terms of cost-effective species benefits.

Note that percentages in the graphs are rounded. For exact numerical values, refer to the data table.

Chart 1: Optimization (ROI) Bar Chart

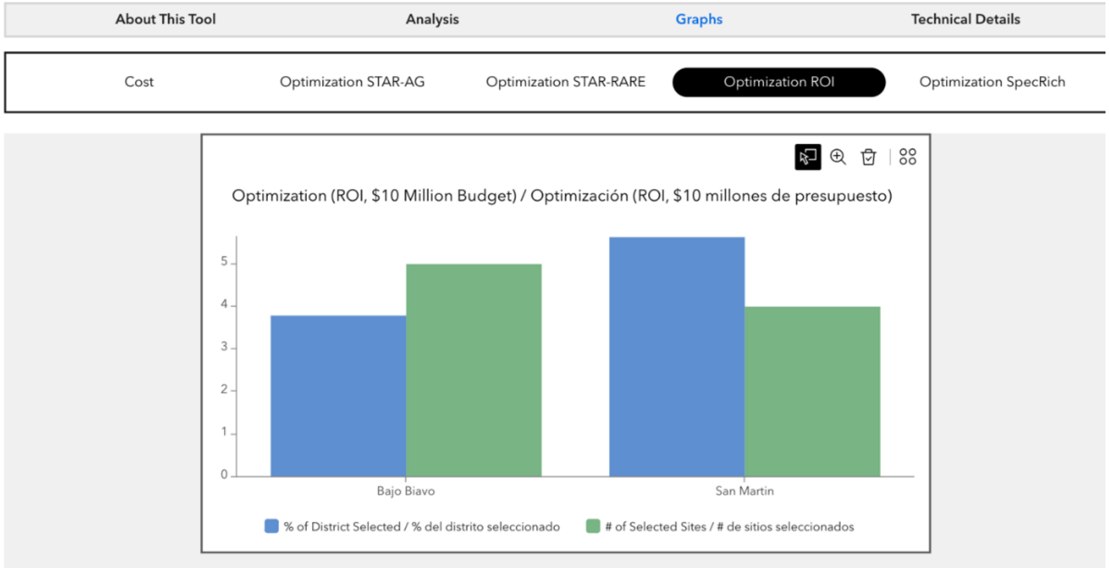
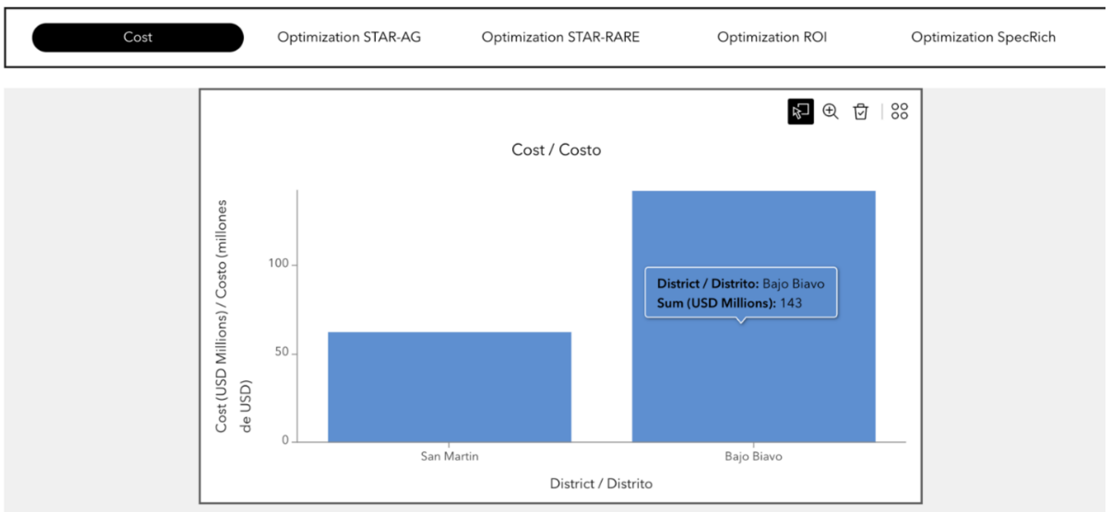


Chart 2: Cost Bar Chart



Summary

- **Bajo Biavo**: Higher total cost and more sites are optimal for agroforestry, but would cover a smaller percentage of the district.
- **San Martin**: Lower total cost and would cover a higher percentage of the district selected, but fewer optimal sites.

By comparing these metrics, you can make informed decisions about where to invest in agroforestry based on cost-effectiveness and conservation impact.

Technical Details

Estimating Biodiversity Benefits from Agricultural Conversion

To quantify the expected biodiversity impact of conversion to agroforestry, we modified the Species Threat Abatement and Restoration (STAR) metric[7]. The STAR metric uses data from the [IUCN Red List of Threatened Species] to quantify how interventions in particular locations can contribute to global sustainability targets. We made two modifications to the STAR metric to specifically estimate the biodiversity response to modifying threats related to agriculture.

Modifications to the STAR metric formulation

The threat abatement component of the STAR metric ($STAR_T$) estimates the value of abating threats to a species in a region based on the species current Red List status and the expected impact of assessed threats on that status across the species range. This value is spatially explicit so the expected impact on species status by abating all threats in a portion of the range can be estimated.

We aimed to estimate the expected change in species' conservation status from abating only those threats reduced by agroforestry and to understand how the consequences varied according to how sensitive the species was to agricultural conversion. Thus, we performed two modifications to $STAR_T$:

1. We considered the spatial distribution of the agricultural threat itself: We restricted potential action areas to sites where agriculture has been confirmed to occur.
2. We considered the severity of how species responded to agricultural threat: The original $STAR_T$ metric used a two-step process to relate population decline to threats according to assessed scope and severity. Our modified approach explicitly categorized species according to the severity of agricultural threats they face to allow us to calculate expected species status improvements related to abating this threat.

Estimating Costs of Conversion

The transition from agriculture to agroforestry generates additional temporary costs for the farmers until the new agroforestry plots can be harvested and are able to produce profit. We estimate the cost of conversion as a subsidy in the amount of the profit differential during this establishment period. To do so, we calculated the Net Present Value (NPV) of expected profit over five years from a well-established coffee or cacao monocrop system and compared it with the NPV of five years of expected returns from a newly established agroforestry system. For these calculations we used a discount rate of 8% and a currency exchange rate of 3.26 PEN for 1 USD.

To calculate the NPV of returns from agroforestry we considered both the establishment costs and the net income after establishment. We considered agroforestry systems that contain three types of species: cacao or coffee, Musaceae species (bananas and plantains), and woody species. We used establishment costs that include supplies, labor, and tools from records in cacao agroforestry plantations in Colombia. We used currency exchange rates of 4,093 COP for 1 USD, and adjusted for the inflation in Perú to get costs equivalent to 2023. We assumed that the net income was two times the net income of the monoculture counterpart for the first five years after establishment of the agroforestry plot, following a comparison in cacao monocultures and agroforestry plots in Bolivia.

We then computed the differences between agricultural and agroforestry NPV for coffee and cacao and calculated a weighted average using the relative proportion of grown area of coffee and cacao. Using maps of agricultural cover in Perú, we calculated the agricultural area in each 1x1 km grid cell and assigned the corresponding profit differential. We assumed that all land currently used for conventional agriculture can be converted to agroforestry.

Calculating Optimal Locations for Action

The optimal location for action depends on conservation goals. This tool allows a user to consider four objectives for action:

- **Improve Status of All Red Listed Bird Species in Region:**
  This analysis identifies optimal locations for agroforestry implementation that maximize improvements in conservation status for all Red Listed bird species in the region. This strategy corresponds with an objective to yield benefits for the widest range of Red Listed bird species.

- **Improve Status of Agriculture-Sensitive Red Listed Bird Species in Region:**
  This analysis identifies areas where a transition to agroforestry practices would maximize the benefits for Red Listed Bird species that are directly and severely impacted by current agricultural methods. This strategy corresponds with an objective to concentrate efforts on species most acutely affected by prevailing agricultural practices.

- **Improve Status of Red Listed Bird Species in Region according to ROI:** This analysis considers the costs of conservation actions and the expected benefits in terms of species protection and habitat preservation when identifying areas that would maximize this.

- **Improve Status of the Diversity of Red Listed Bird Species in Region:** This analysis identifies areas where a transition to agroforestry practices would maximize the diversity of species within the selected region. This is a fundamental aspect of biodiversity and contributes to a healthy and resilient ecosystem.

See Guerrera-Pineda, 2024 (https://keep.lib.asu.edu/items/197738) for more details.

Interpreting the Results

Interpretation of the results generated by this tool should consider:

- The desired balance between cost-effectiveness and conservation impact
- Long-term sustainability of agroforestry projects in selected areas
- Alignment with local and national conservation priorities
- Potential socio-economic benefits for local communities

The Red List species data underlying these analyses are the best available information, but users should remember that they are based on species assessments that are updated relatively infrequently, are limited to bird species that have been assessed, and include range estimates that may not be reliable for fine scale decision making.