Microsoft

AI for Earth Grantee Profile

Rainforest Alliance

Machine learning models for sustainable cocoa farming

Summary

Climate change is threatening the livelihoods of 5 million smallholder cocoa farmers who produce roughly 90 percent of the world's cocoa supply. The Rainforest Alliance is using its Microsoft AI for Earth grant to develop a machine learning model to predict cocoa yield and a customized digital dashboard in ArcGIS Pro that will help farmers optimize their agricultural practices and improve their incomes more sustainably.

Supporting sustainable livelihoods for the world's cocoa farmers

The global demand for cocoa has sustained the livelihoods of more than 5 million smallholder farmers from Latin America and Southeast Asia to West Africa, where nearly 70 percent of the world's cocoa is now produced. In leading exporters, like Ivory Coast and Ghana, up to 90 percent of farmers rely on cocoa as their primary source of income. This leaves them highly vulnerable to climate-related crop loss, which has driven many farmers to unsustainable measures in an attempt to improve their yields and support their families.

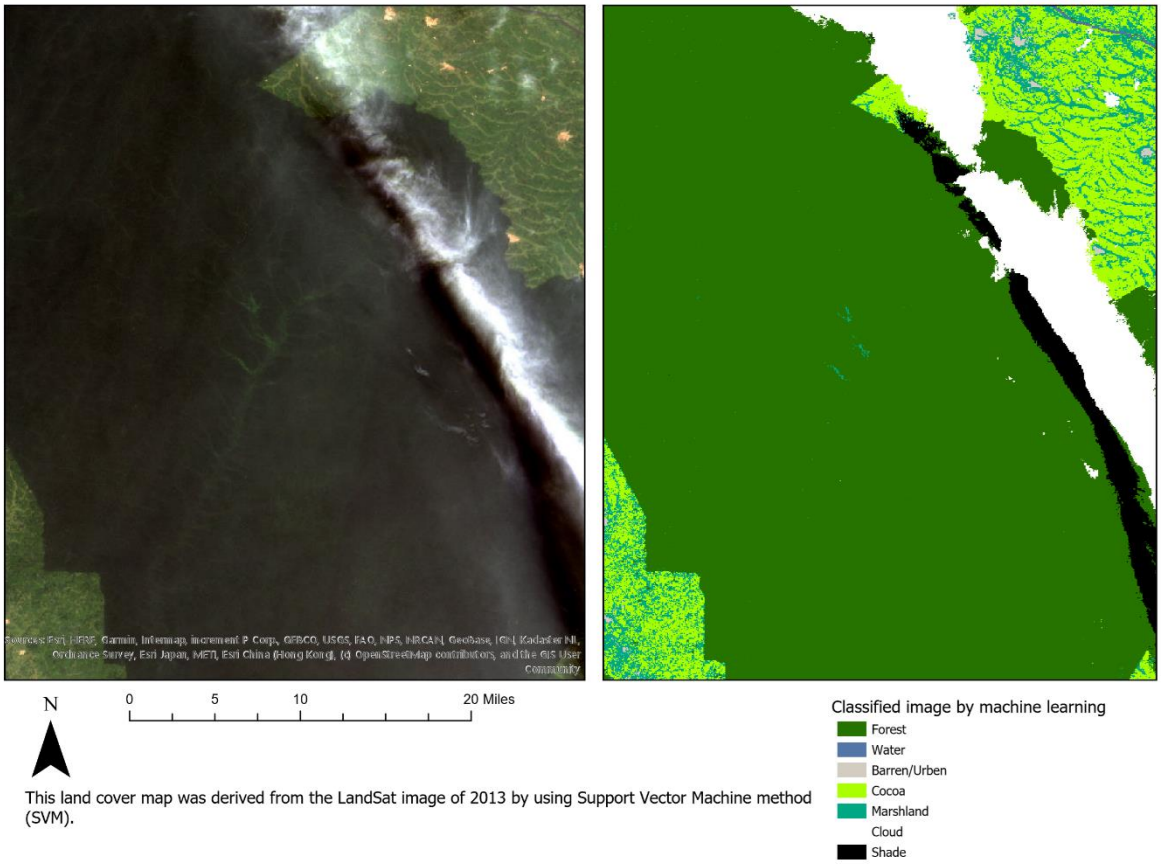
> "Among the world's five million smallholder cocoa farmers… rigorous training in efficient and sustainable farm management is essential to stabilizing their microclimate and stopping the destructive cycle of poverty and deforestation."—Rainforest Alliance

Cocoa is a particularly sensitive crop. As global temperatures rise and draw moisture out of the soil, one of the most important factors for maintaining the productivity of cocoa crops the world over is their proximity to shade trees, which help maintain soil moisture and fertility. Thus, many cocoa farmers are pushing the borders of their farms farther into the surrounding rainforests in pursuit of shade and richer soils. But this only further destabilizes the local ecosystem and exacerbates problems like deforestation, soil erosion, and habitat loss for local wildlife, including native bird species like the Little Greenbul and the Great Blue Turaco.

To help break what it has described as a "destructive cycle of poverty and deforestation," the Rainforest Alliance is using its Microsoft AI for Earth grant to estimate the number and distribution of shade trees on cocoa farms, in order to help farmers maximize their yields more sustainably, without expanding into the forests.

Mapping the risk of deforestation

The Rainforest Alliance is an international nonprofit organization working at the intersection of business, agriculture, and forestry to enhance responsible business practices. One tool the organization has created in order to achieve this mission is the Rainforest Alliance certification program. Their green frog certification seal can be found on products such as chocolate, coffee and tea. It indicates that the ingredient has been sourced from a farm that has been audited to meet standards that require environmental, social, and economic sustainability.



Land cover map of tropical rainforest with surrounding cocoa farms.
[Image credit: Rainforest Alliance]

Since agriculture is responsible for at least 80 percent of tropical deforestation worldwide, being able to verify that a product like cocoa does not come from an area that has been linked with deforestation is essential to ensuring accountability in the certification process. But this requires a sophisticated view of individual crop borders for millions of smallholder farms globally and the ability to monitor whether they are encroaching on the surrounding rainforest land over time—all at fine-scale resolution.

To achieve this monitoring capability, a team at the Rainforest Alliance used 2013 satellite imagery and AI-enabled mapping tools from Microsoft and Esri (via a joint product called the Geo AI Data Science Virtual Machine, or Geo AI DSVM) to create a forest base layer map of cocoa hot spots, like the Ivory Coast. These detailed maps provide critical information about parts of the country that are most threatened by deforestation, so the alliance can avoid certifying products from those areas and help mobilize strategic conservation efforts. For example, the Rainforest Alliance is now working with six cocoa farming communities in the Ivory Coast to develop a land management board that will help protect Taï National Park, one of the last remaining primary rainforests in West Africa.

This type of base map wouldn't be possible without the advanced mapping capability of the Geo AI DSVM, which seamlessly integrates Esri ArcGIS software with Microsoft AI tools, creating a convenient and powerful tool for processing geospatial data at scale. And the Rainforest Alliance team also made use of ArcGIS Notebook—a coding platform that is similar to Jupyter Notebook, but with the added benefit of being built right into the ArcGIS environment.

> "The grant resources and training, including access to Microsoft's virtual machine, have enabled us to realize the full potential of our data."— Laybelin Dijkers, Senior GIS Specialist at the Rainforest Alliance

Using machine learning to calculate optimal shade tree distribution

In addition to mapping the precise area and locations of cocoa farms in order to identify and protect at-risk forestland, the Rainforest Alliance is also developing a new machine learning algorithm to help estimate the type and percentage of shade trees within their borders. This is important to help farmers understand where they may need to plant additional shade trees, in order to improve the output of their crops without encroaching on the surrounding forests.

But it requires vast amounts of high-quality remote sensing data to train the new model effectively, and to attempt this with high-end, subscription satellite image services would be far too expensive for the Rainforest Alliance to replicate on a global scale. Imagery from public sources (like the United States' Landsat 8 or Europe's Sentinel-2) is more cost-effective but must still be ground-tested for accuracy. Drones are one option for obtaining an accurate tree count for individual farms; but they, too, are expensive and, in some places, illegal to fly. So, the alliance developed an alternative method to systematically ground-truth their shade tree estimates—field surveys.

Shade trees identified with the Rainforest Alliance's machine learning model. [Image credit: Rainforest Alliance]

During a successful pilot project in Indonesia, surveyors annually visited cocoa farms on the island of Sulawesi to collect detailed crop information on everything from the number of shade trees to soil moisture and fertility to farmers' practices for weeding, pruning, fertilization, and pest control. This data was then digitized and combined with remote sensing data to create a machine learning algorithm that is able to produce accurate shade tree counts and tailored yield predictions for Indonesian cocoa crops, helping farmers there optimize their harvests more sustainably.

But more data is needed to further refine the training model for international adoption—especially since the ideal distribution of shade trees for cocoa can range from 12 to 144 trees per hectare, depending largely on the region and the species of shade trees that grow there.

Helping farmers maximize their cocoa yields with a custom AI dashboard

With continued support from Microsoft's AI for Earth program, the Rainforest Alliance is now scaling its shade tree model and expanding the impact of proven community engagement programs globally. Access to robust tools like Microsoft Machine Learning Studio enables the ongoing refinement of current algorithmic yield predictions, while Azure cloud storage allows the alliance to scale its computing power as needed to accommodate additional data layers, such as precise farm location data.

Rainforest Alliance staff with cocoa farmers in Ghana. [Image credit: Rainforest Alliance]

In order to provide farmers with more tailored recommendations for how to boost the yield of their cocoa crops, the Rainforest Alliance has also used its AI for Earth grant to create a dashboard in ArcGIS Pro that delivers customized data insights directly to local farming communities. The new educational tool uses digital technology, satellite imagery, and the predictive capability of the Rainforest Alliance's machine learning algorithm for predicting crop yield, to create individual Farm Development Plans (FDPs) that advise farmers on the optimal distribution of shade trees for their locale, as well as other sustainable farming practices. This process is facilitated by in-country field agents who provide farmers, including women and youth, with unprecedented access to detailed crop data on their mobile devices during community education seminars—along with investment advice, certification training, and other data-driven guidance for sustainable climate-adaptation.

Going forward

The Rainforest Alliance plans to continue fine-tuning its model for predicting crop yield to include more variables and geographic regions. In the future, it also sees potential for applying the model to other crops, like coffee and bananas, which have also been linked to deforestation globally.

About Rainforest Alliance

The Rainforest Alliance is an international non-profit organization working at the intersection of business, agriculture, and forests to make responsible business the new normal. It is an alliance of farmers, forest communities, companies and consumers committed to creating a world where people and nature thrive in harmony. The Rainforest Alliance is working to solve some of the most urgent environmental and social challenges of our day, from deforestation, climate change, and biodiversity loss to entrenched rural poverty. They're implementing proven and scalable solutions on the ground, while testing innovative ways to drive change.

Resources

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Websites

Rainforest Alliance website
Rainforest Alliance Certified Cocoa website
Rainforest Alliance report: "Key Findings on Shade Trees"