POLICY BRIEF:

Cost-Benefit Analysis of Climate-Resilient Coffee Production

AN INDONESIA CASE STUDY

WINROCK INTERNATIONAL

Private Investment for Enhanced Resilience project

Cost-Benefit Analysis and Climate Change Adaptation

The Private Investment for Enhanced Resilience project (PIER), funded by the Bureau of Oceans and International Environmental and Scientific Affairs in the U.S. Department of State (DOS) conducted a cost-benefit analysis of climate-resilient coffee production in Indonesia. Building on several activities PIER implemented to address the challenges of promoting climate-resilient value chains, including coffee, Winrock International's PIER team collaborated with University of Wisconsin-Madison graduate students to better understand how climate change impacts (such as drought, increased temperature, and rainfall variability) contribute to food and income insecurity of smallholder farmers worldwide.

Smallholder farmers (SHFs) account for 95% of coffee produced in Indonesia (Dalberg, 2015), and climate change is expected to affect rainfall and temperature, posing challenges for arabica coffee cultivation. Predictions include the following:

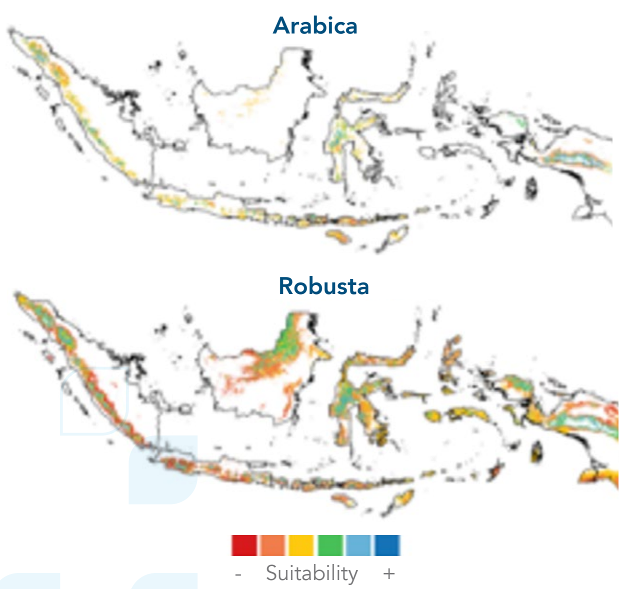
> Rainfall will be more variable with frequently- delayed monsoon rains, intermittent rain during the dry seasons, and more extreme weather events, thereby decreasing yields and interrupting coffee production.

> Sub-optimal temperatures will decrease the quantity and quality of coffee production and make it more vulnerable to pests and diseases.

As a result, even with adaptive strategies to mitigate the effects of climate change in coffee production, the land suitable for cultivation of arabica coffee is projected to be reduced to two-thirds of the current area (Figure 1, IDH, 2019).

FIGURE 1. SUSTAINABLE TRADE INITIATIVE (IDH) PROJECTION

Changes in suitability between today and 2050



Climate-smart agriculture practices can increase the resilience of SHFs, but the combination of practices that yield the greatest economic return is not always clear. Cost-benefit analysis (CBA) is a useful methodology and decision-making tool to identify adaptation solutions (FAO, 2018). CBA has been identified by the United Nations Framework Convention on Climate Change (UNFCCC) as a method to help prepare National Adaptation Plans by ranking and prioritizing adaptation options in terms of their costs and benefits to society (UNFCCC, 2012).

The PIER CBA identified potential climate-smart practices and financing options to encourage SHFs to invest in climate-resilient strategies to maintain arabica yields in the face of rising temperatures and changing precipitation patterns.

Method and Model Specification

The analysis focused on coffee farmers in the Lake Toba region of North Sumatra, which has approximately 4,000 SHFs who cultivate arabica. Coffee yield is affected by farm management practices, environmental conditions, and coffee variety, with production typically beginning to decline once trees are 15-20 years old (Dalberg, 2015).

PIER identified the baseline conditions of the supply chain for average farm-level economics, value chain economics, expected climate change impacts on coffee farms, and access to finance. The analysis then identified specific costs and benefits (Table 1) for two potential adaptation options:

> **Option 1:** Implement training campaigns for SHFs on climate-smart agricultural practices without providing financial assistance.

> **Option 2:** Combine the training campaign from Option 1 with financial assistance to help SHFs invest in renovation (cutting and replacing old trees with new seedlings) and/or rehabilitation (extensive pruning).

Climate-smart practices (such as the appropriate use of fertilizers, integrated pest management, and crop diversification) can reduce climate risks and increase yields. However, use of these practices can be costly for SHFs who have very limited financial means. Therefore, training alone may not lead to sufficient buy-in among farmers to generate net-positive benefits.

TABLE 1. TYPES OF COSTS AND BENEFITS USED FOR ANALYSIS
(NOTE THAT QUANTITIES OF COSTS AND BENEFITS DIFFER BY OPTION.)

OPTION	BENEFITS	COSTS
Option 1: **Training**	• Increased yields • Decreased crop loss • Increased resilience	• Training program costs • Opportunity costs of attending training • Annual costs of cultivation
Option 2A: **Training and 100% renovation**	Same as above (SAA)	SAA, plus: • Initial costs of renovation • Initial decrease in yields
Option 2B: **Training and 100% rehabilitation**	SAA	SAA, plus: • Initial decrease in yields
Option 2C: **Training and 50% renovation and 50% rehabilitation**	SAA	SAA, plus: • Initial costs of renovation • Initial decrease in yields

Additionally, renovation and rehabilitation are potential solutions to increase yields. Renovation provides an opportunity to install newer or more resilient coffee varieties and establish shade trees that mitigate risk of increased temperatures (Dalberg Advisors, 2017), while rehabilitation includes extensive pruning of low-yielding branches. Both renovation and rehabilitation require extensive capital and entail tradeoffs in production and income. Renovation is the most capital intensive for farmers, with labor costs incurred to remove existing trees, obtain new seedlings to replant farms, to obtain additional tools and fertilizer, and to cover maintenance costs before farms start reproducing. Newly-planted seedlings take 3-4 years before they begin producing beans. They reach maximum yields by year eight, thus requiring farmers to seek alternative sources of income while their farms are renovated. Conversely, rehabilitation is less capital-intensive, using heavy pruning rather than replacement of old coffee trees; however, rehabilitation does not produce the same yield boost as renovation (Dalberg, 2015).

This analysis explored whether the benefits of rehabilitation and/or renovation, along with training on climate-smart practices, are sustainable in the long-term to justify the considerable investment and production losses in the short-term.

The analysis assumed that training and information campaigns were held each year to encourage farmers to implement climate-smart practices, leading to an ever-increasing rate of commitment from farmers. It applied benefits and costs from trainings to both Option 1 and Option 2.

The analysis considered three benefit categories in calculating net-present value for Option 1 and Options 2A, 2B, and 2c for farmers adopting climate-smart practices, with and without undertaking renovation and/or rehabilitation. Those categories are: 1) Increased yields; 2) Increased climate-resilience (shown through a decrease in year-on-year production losses that generate more revenue); and 3) A decrease in annual crop loss.

Costs included training costs, increased costs of annual cultivation with the implementation of climate-smart practices, and opportunity costs for farmers who attended trainings.

In addition, Option 2 has additional cost categories given its three scenarios:

- **Option 2A:** Training and 100% renovation;
- **Option 2B:** Training and 100% rehabilitation; and
- **Option 2C:** Training, 50% renovation, and 50% rehabilitation.

For Options 2A and 2C, the initial cost of renovation was applied, which includes costs of purchasing new seedlings to replace existing trees, extra labor costs for removing/composting old trees and planting new seedlings, and additional costs of tools and fertilizer. These costs apply to the first year of the intervention. For options 2A, 2B, and 2C, the initial decrease in yield that farmers will see following a cycle of renovation or rehabilitation was also applied. Farmers cannot expect their crop yield to cover their costs of cultivation during this period and must plan to live off savings or other income.

The analysis compared all options and scenarios against a baseline case, which assumed that no training occurred after 2020, and that farmers did not take up climate-smart practices, renovation, or rehabilitation.

Analysis and Results

The analysis modeled costs and benefits of all scenarios over a 20-year period using a discount rate of 10%. The results showed that implementing a training campaign in addition to providing financial assistance to farmers to pursue 100% renovation yielded the greatest net benefits. Table 2 summarizes the results of the CBA expressed in terms of the net- present value for the baseline, Option 1, and Option 2, including three combinations of renovation and rehabilitation.

TABLE 2. CBA RESULTS(WITH NET-PRESENT VALUE REPRESENTING THE LOWER BOUNDS.)

Adaptation Options	Net Present Value
Baseline	$5,655,237
Option 1: **Training**	$7,153,796
Option 2A: **Training and 100% renovation**	$18,300,000
Option 2B: **Training and 100% rehabilitation**	$14,860,280
Option 2C: **Training and 50% renovation and 50% rehabilitation**	$17,259,080

Implementing 100% renovation in conjunction with training (Option 2A) provides the greatest net benefits because the increased yields from renovation far exceed those from better practices alone, even accounting for a decrease in production in the initial years. The largest benefit from this scenario is the increase in yields (and therefore, income), while the biggest cost is for the farmers to attend the training. Given that the cost of training remains the same for all scenarios and the cost of decreased yields in Option 2A would be covered by the provision of financial assistance in the form of loans, the substantially-higher yields of loan-funded investments mean this scenario has the highest net-present value and is the best strategy for promoting climate-resilient practices to help SHFs.

Limitations

Uncertainty around climate projections and the number of adaptation options analyzed comprise the study's main limitations. If project scope and resources permitted, additional adaptation options could have enhanced the analysis. Primary and secondary research, including field surveys and stakeholder consultations, mitigated these limitations, enabling capture of the most up-to-date information and best options available to farmers.

Broader Application

This analysis explored whether the benefits of rehabilitation and renovation, along with training on climate-smart practices, are sustainable in the long-term to justify the considerable investment and production losses in the short-term. Overall, the analysis points to a potential adaptation solution: implementing 100% renovation in conjunction with training, which could be further analyzed based on farmer capacity, preferences, and access to financing options.

Making decisions about climate-smart agriculture options requires an understanding of tradeoffs. CBA provides one approach to analyze the potential risks, impacts, and benefits of various solutions. This method is customizable and can be applied by donors, government actors, cooperatives, and other decision-makers to identify adaptation solutions. By understanding these tradeoffs, CBA can help channel investments efficiently and effectively to enhance food security and resilience.

Sources

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Private Investment for Enhanced Resilience

PIER is a 5-year (October 2017– August 2022) technical assistance project, funded by the United States DOS, that aims to address barriers the private sector faces to increasing investment in climate-resilience activities in 12 developing countries. The objective of PIER's technical assistance is to influence enabling environments for investments that reduce long-term environmental risks while increasing resilience in development sectors prioritized by counterpart communities.