TechnoServe
Business Solutions to Poverty™

Building the Case for Regenerative Coffee Production

Brazil Arabica

April 2025

Coffee growing on a hillside in Jinotega, Nicaragua. (TechnoServe)

Nestlé

Rudy & Alice Ramsey Foundation
Life Is Not a Zero-Sum Game

JDE Peet's

Coffee Sector Transformation through Regenerative Agriculture

The Challenge

- **Coffee is a vital sector of the economy.** Coffee sustains 12 million smallholder farms supporting 60 million individuals worldwide, while serving as a critical export and foreign currency source for many global south economies.

- **Coffee farming is under pressure.** Long-standing challenges to coffee farmer profitability — like land fragmentation and limited access to best practices or investment — are being intensified by climate change. Most farms are ill-equipped to withstand climate shocks or adapt to rising temperatures and shifting weather patterns.

- **In many regions, current farming practices are depleting the very natural resources they depend on.** Carbon emissions, water overuse, soil degradation and natural habitat loss further threaten long-term production viability.

The Opportunity

- **Regenerative agriculture, an approach to farming that regenerates soils, improves the water cycle, and increases biodiversity and climate resilience, is hailed as a solution to these challenges.**
- The objective of this study is to provide the evidence base to assess this opportunity, by addressing a few fundamental questions:
  1. Can environmental, economic, and market priorities be aligned effectively?
  2. How do solutions need to be adapted across diverse growing regions?
  3. What specific investments would enable successful transition?
  4. How can the business case resonate with all stakeholders?

This roadmap presents a practical transition to regenerative farming that can be achieved at scale and with a positive investment case for farmers, nature, industry and governments.

In Brazil, global leader in Arabica production, a viable path towards large-scale regenerative farming starts with reducing carbon emissions by about half

ECONOMY
Exports

<1%

increase in country exports *of Arabica*[1]

PEOPLE
Farmer Income

10%

increase in income *for 96,000 farms*[2]

NATURE
GHG Emissions

46%

decrease in coffee emissions[3] *across 478,000 coffee hectares*

[1] Assumes all incremental production is absorbed by export markets

[2] Assumes 50% adoption of regenerative practices among the 6.5 million smallholder farms within selected origins and archetypes

[3] Variance in GHG emissions for coffee produced on farms that adopt selected regenerative practices. Figures obtained by manually uploading data into Cool Farm Platform GHG module. Emissions sources and sinks (a) included in all analysis: crop details, crop residues, pesticide, fertilizers, non-crop estimates; (b) included only if relevant to production system: wastewater, fuel and energy, irrigation energy; (c) excluded from all analyses: transport, re/deforestation, soil carbon changes, machinery operations.

Decarbonization benefits make the business case highly compelling for investors

Investment Required[1]

$155 Million p.a. over 7 years

Drives broader sector value[2]...

$16 Million
additional Arabica exports p.a.

...Supporting farmer livelihoods[3]...

$64 Million
additional farm income p.a.

...and delivering a vision of a low carbon sector[4]

1.6 Million
MT *CO_2e abated p.a.*

Business Case for Investment in Brazil (Arabica)

From a decarbonization perspective, the investment case is highly compelling. Supporting around 100k small coffee farms (with <10 hectares of coffee) to adopt proposed practices can cut GHG emissions by 1.6 million MT CO_2e per year, reducing GHG footprint by 46%, at an equivalent abatement cost[5] of $26/ MT CO_2e. This is the single largest source of carbon abatement across all countries in this study, representing ~50% of the global opportunity. However, for the economics to work for farmers, a viable business model for establishing on-farm composting infrastructure is crucial.

Additional Benefits of Proposed Transition

Optimizing organic and synthetic fertilizer application, implementing consistent compost management, cover crop and soil amendments, and decreasing use of agrochemicals across almost 500k ha, will contribute to soil health improvement, water retention and quality, and soil microbial diversity. Still, to meaningfully build resilience and adapt to climate shifts, farmers will need to transition away from a full-sun monoculture production system, as described below.

Future Steps in Journey Towards Regenerative

The proposed roadmap can create momentum behind the decarbonization of Brazil's Arabica sector, further unlocking investment for practices that have additional direct benefits to farmers and nature. These include rejuvenation, use of improved varieties, and IPDM (for income benefits) and agroforestry (for biodiversity and water retention benefits). The full suite of practices would strengthen farm resilience to drought and frost, which are becoming more frequent and have destabilizing effects to global markets given Brazil's share of global production. Corresponding costs and impacts can be overlaid onto this analysis to quantify the investment case for a more holistic regenerative transformation.

[1]Sum of investments needed over a 7-year transition period; [2] Assumes all incremental production is absorbed by export markets; [3]Farmer net income at steady state versus baseline for farms that adopt selected regenerative practices, assumed as 50% of all farms in the archetype [4] Variance in GHG emissions for coffee produced on adopting farms, based on Cool Farm Platform. [5] Over 25 years once steady-state conditions are reached. See appendix for detailed calculation inputs and assumptions.

A In Brazil, experts predict an 18% decrease in land suitable by 2050 and more volatile production volumes due to rising temps., changing rainfall, and droughts

Effects of climate change on local environment

Gradual climate shifts

Rising temperatures
- Temperature projections vary widely
- Average of 21 models project increase of up to 3.5 degrees Celsius over most of the country by 2100

Changing seasonality
- Dry season in the Amazon will get longer and precipitation will decrease, especially in the dry season

Changing rainfall
- 5% increase in rainfall in western Brazil
- Rainfall decreases of up to 5% in central, north, and southeastern Brazil

Extreme weather events

Frequent droughts
- Increased drought and increased length of dry period are expected due to stronger and frequent El Nino events

Impact on coffee production absent adaptation

- Land suitable for coffee production estimated to be reduced by at least 18% by 2050 and 27% by 2070
- Limited potential to shift production to higher elevations

- Lack of rainfall during cherry development period will lead to smaller bean sizes, i.e. lower quantity and quality

- Stress caused by heat and drought increases the susceptibility of coffee trees to pests and diseases

- Shade trees and irrigation may be needed to cope with higher evapotranspiration and decreasing rainfall

- **Increased volatility of production volumes**, *e.g. a combination of* ***severe drought and frost in 2021 affected ~1.5M km of Arabica coffee farms*** *and is* ***destroyed ~20-30% of Brazil's total Arabica production***

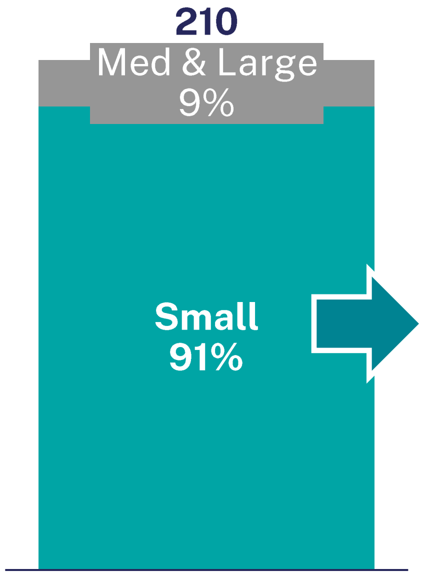
Without adoption of regenerative practices to fuel adaptation,
yield likely to decline over the medium term and ~17% of total production at risk annually from more frequent weather events

Sources: Coffee production in the face of climate change: country profiles (IDH, 2019); Climate risks and vulnerabilities of the Arabica coffee in Brazil under current and future climates considering new CMIP6 models (Dias et al, 2024); Brazil: Coffee Annual (USDA, 2021); Coffee: World Markets and Trade (USDA, 2024)

A This business case analysis is focused on high input use, full-sun, rain-fed Arabica coffee farms under 10 hectares; total ~190k Arabica farms, ~ 1 million hectares

Farm size breakdown[1]
% of total Arabica farms

Selected archetype



Total Arabica farms ('000)

190k Arabica farms

~60% of national Arabica production

~1 million hectares

Additional descriptors of selected archetype

Arabica
Brazil is largest global Arabica producer. 73% farmers produce Arabica coffee[3]

Rain-fed
Most Arabica coffee is produced without irrigation due to high cost

High Mechanization
Significant mechanization in harvest and post-harvest practices

Full-sun
Shade-grown coffee is uncommon in Brazil due to optimization of productive area

High Input Use
Chemical fertilizers and agrochemicals are used intensively

Dry hulling[2]

[1] Small (<10ha), Medium (10-100ha), Large (>100ha) IDH (2014), GCP (2017), Enveritas (2018) [2] Analysis considers only on-farm processing. Archetypes that process coffee off-farm are denoted as "No on-farm processing" for the purpose of our analysis. [3]IDH Source: TechnoServe analysis & expert interviews
See appendix for descriptor definitions

A While some regenerative practices are already known to farmers...

Pillars		Current adoption of practices	
1	Renovation, Rehabilitation, and Coffee Varieties	Pruning	✓✓✓
		Rejuvenation (incl. stumping)	✓✓
		Grafting	N/A
		Replanting	N/A
		Use of improved varieties	✓✓✓
		Variety diversification[2]	✓
2	Agroforestry systems & Shade	Shade management	
		Shade tree species diversity	
3	Soil conservation and Cover cropping	Cover cropping	✓
		Intercropping	✓
		Physical structures	✓
		Contour planting	✓
		Minimizing soil disturbance	✓
4	Integrated Weed Management (IWM)	Mulching w/ organic residue	✓✓
		Physical control of weeds	✓✓
		Spot chemical applications	✓

Pillars		Current adoption of practices	
5	Integrated Pest & Disease Management (IPDM)	P&D identification & monitoring	✓✓
		Field hygiene practices	✓✓✓
		Biological control	✓
		Traps	
		Precision application of selective pesticides	✓✓✓
6	Integrated Nutrient Management (INM)	Soil analysis & field observation	✓✓
		Soil amendments	✓✓
		Composting & vermi-composting	✓
		Optimal fertilizer mgmt. (4R strategy)	✓✓✓
		Biofertilizers and/or beneficial microorganisms	✓
7	Efficient Water Use	Rainwater harvesting	
		Improved irrigation management	N/A
		Efficient water use in post-harvest processing	N/A
8	Wastewater Management	Wastewater treatment	N/A
9	Waterbody Protection	Riparian buffers	✓✓✓
10	Waste valorization & production of organic inputs	Biochar production	
		Anaerobic digestion	N/A

( ) < 5%
✓ 5 - 30%
✓✓ 30 - 60%
✓✓✓ > 60%

A ...Scaling and refining proven solutions that deliver both economic and environmental benefits is the most promising pathway to advance the transition

Opportunities for farms within archetype, given baseline practices

Regen. Ag. practice pillars prioritized based on based on assessment of relative impact on GHG mitigation and coffee farm income. Included in GHG and farmer business case analysis

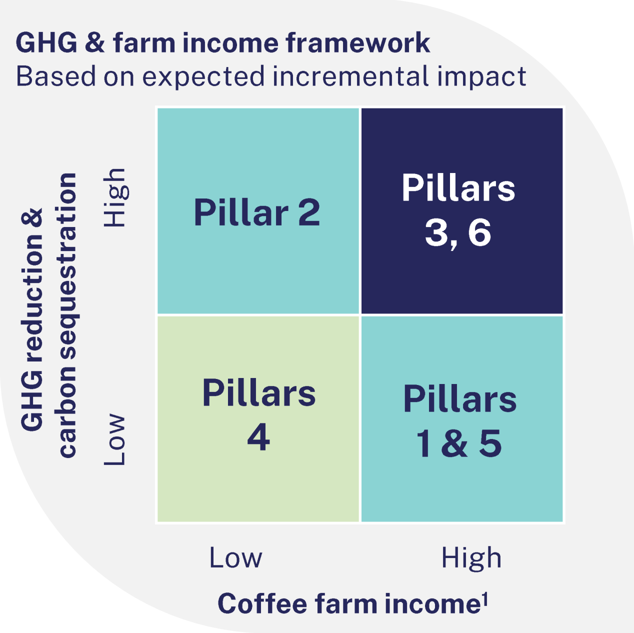
	Practices	Short/medium-term incremental opportunities
1	Renovation, Rehabilitation, and Coffee Varieties	➢ Establish long-term (>10 years) rejuvenation plans tailored to individual farms[1] ➢ Adopt existing varieties that are resistant to local pest and diseases
2	Agroforestry systems and Shade	➢ Individualized planning. E.g.: shade tree rows, like avocado, every 10 rows of coffee
3	Soil conservation and Cover cropping	➢ Plant cover crops that fixate nitrogen, attract natural enemies, and/or increase organic matter (e.g.: brachiaria, buckwheat, forage radish) ➢ Intercrop with crops when coffee is younger ➢ Implement crops as physical structures that can attract natural enemies or diversify income
4	Integrated Weed Management (IWM)	➢ Improve mulching by combining inputs from the coffee farm and neighboring farms ➢ Use weeding instruments that don't damage the soil (e.g.: mechanical trimmer, ecological brush cutter) ➢ Decrease the amount of herbicide applied by applying it only to harmful and aggressive weeds

	Practices	Short/medium-term incremental opportunities
5	Integrated Pest & Disease Management (IPDM)	➢ Increase adoption of biologicals and promote new biologicals use ➢ Establish a pest pressure monitoring system to enable more targeted responses to pest outbreaks
6	Integrated Nutrient Management (INM)	➢ Interpret soil analysis and plan farm's activities accordingly ➢ Implement basic soil amendments inputs accordingly to results of soil analysis ➢ Implement composting, apply organic minerals and other organic fertilizers by using inputs from the farm or from local farms
7	Efficient Water Use	*Not applicable to farmer archetype*
8	Wastewater Management	*Not applicable to farmer archetype*
9	Waterbody Protection	*No opportunities identified*
10	Waste valorization & Production of organic inputs	*No opportunities identified*

For additional detail on baseline practices, barriers to adoption and incremental opportunities, see appendix 2

[1]Not opportunity for yield improvement due to already high adoption

B For Arabica farms within this archetype, soil conservation and cover cropping; integrated nutrient mgmt. deliver the highest potential GHG and income impact



GHG & income pillars	Specific practices	GHG impact area(s)	Income impact area(s)
3 **Soil conservation and Cover cropping**	➢ Cover cropping ➢ Intercropping ➢ Physical structures (e.g., windbreaks)	• Optimize yield • Reduce quantity of synthetic fertilizer • Reduce insecticide use	• Increase coffee production • Diversify income • Reduce costs of production • Improve farm resilience to shocks
6 **Integrated Nutrient Management (INM)**	➢ Soil analysis & field observation ➢ Soil amendments ➢ Composting	• Optimize yield • Reduce quantity of synthetic fertilizer • Improve crop residue & waste mgmt.	• Increase coffee production • Improve farm resilience to shocks

Other regen. pillars	Specific practices	GHG impact area(s)	Income impact area(s)
1 **Renovation, Rehabilitation, and Coffee Varieties**	➢ Rejuvenation ➢ Use of improved varieties	• Reduce fungicide use	• Reduce costs of production • Improve farm resilience to shocks
2 **Agroforestry systems & Shade**	➢ Shade mgmt. ➢ Shade tree species diversity	• Increase tree biomass • Reduce insecticide use	• Diversify income • Improve farm resilience to shocks
4 **Integrated Weed Management (IWM)**	➢ Mulching w/ organic residue ➢ Physical control of weeds ➢ Spot chemical application	• Reduce herbicide use • Improve crop residue & waste mgmt.	• Reduce costs of production • Improve farm resilience to shocks
5 **Integrated Pest & Disease Management (IPDM)**	➢ Biological control ➢ Precision application of selective pesticides	• Reduce insecticide use	• Reduce costs of production • Improve farm resilience to shocks

[1]Defined as long-term potential income from coffee growing area (including income from intercrops)
Note: Some pillars excluded from prioritization as they were not applicable to farmer archetype (efficient water use, wastewater mgmt) or did not have short/medium-term feasible opportunities (waterbody protection, waste valorization & production of organic inputs)

C Selected pillars also provide other environmental benefits related to soil health, water conservation and quality, and biodiversity and land use

Impact area(s)

GHG and income pillars	Specific practices	Soil health	Water conservation and quality	Biodiversity and land use
3 **Soil conservation and Cover cropping**	➢ Cover cropping ➢ Intercropping ➢ Physical structures (e.g., windbreaks)	● (Very high) • **Reduce loss of fertile topsoil** • **Improve soil temperature**, aeration, porosity	◕ (High) • **Improve water infiltration and retention**	◕ (High) • **Provide habitats** for functional biodiversity with cover crops
6 **Integrated Nutrient Management (INM)**	➢ Soil analysis & field observation ➢ Soil amendments ➢ Composting	◕ (High) • **Stimulate nutrient cycling and retention** with combined use of mineral fertilizers, organic resources, and soil amendments • **Strengthen soil carbon stocks** with organic inputs	◕ (High) • **Reduce nutrient losses from volatilization and leaching**, thus reducing contamination of water bodies with excess nutrients • **Enhance soil water retention** with improvements in organic resource management	◕ (High) • **Support soil microbial diversity** with a balanced and nutrient-rich soil environment • **Help to protect wild biodiversity on farm and in the surrounding landscape** with reduced eutrophication

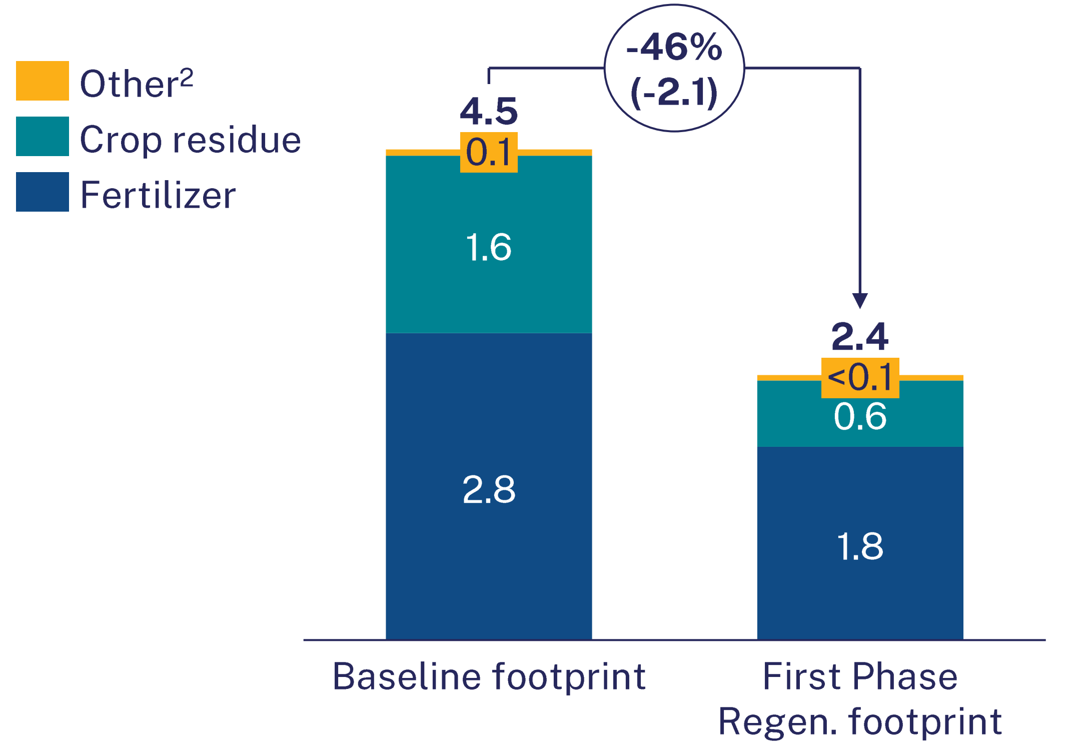
Approx. level of impact: ● Very high ◕ High ◑ Medium ◔ Low ○ Very low

Other regenerative pillars (1, 2, 4, 5 on previous slide) can also contribute significantly to soil health, water conservation and quality, and biodiversity and land use. See appendix 1 for further details

Sources: CIAT (2023), TechnoServe analysis & expert interviews

D Scaling up adoption of composting, combined with reduction in synthetic fertilizer, can nearly halve GHG emissions

GHG footprint under first phase of regenerative adoption[1]
Kg CO_2e/Kg GBE



- **GHG emissions projected to decrease by 46%**
- Emissions reduction primarily due to a 63% reduction in emissions from crop residues, enabled by **composting on-farm organic matter** rather than leaving residue on field, and a reduction in fertilizer footprint from **substitution of synthetic fertilizer with compost** produced on farm
- Expected increase in productivity is relatively minor, at 5%, barely having an impact on the change in emission factor

[1] Variance in GHG emissions for coffee produced on farms that adopt selected regenerative practices. Figures obtained by manually uploading data into Cool Farm Platform GHG module. Emissions sources and sinks (a) included in all analysis: crop details, crop residues, pesticide, fertilizers, non-crop estimates; (b) included only if relevant to production system: wastewater, fuel and energy, irrigation energy; (c) excluded from all analyses: transport, re/deforestation, soil carbon changes, machinery operations.
[2] Includes emissions from phytosanitary products, fuel use, and removals from agroforestry
Sources: TechnoServe analysis & expert interviews
See appendix for calculation inputs and assumptions

E While impact on the farm's operating costs is mostly neutral, a sizeable upfront investment is needed for compost production equipment

YoY Change ($/ha)	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Synthetic fertilizers	1,031	0	155	103	103	0	0	670
Other	1,169	450	11	11	0	0	0	1,597
Labor	1,090	36	0	0	0	0	0	1,126
Upfront investments		1,310						
Total costs[1]	**3,433**	**5,229**	**3,753**	**3,639**	**3,536**	**3,536**	**3,536**	**3,536**
% change vs. baseline		**52%**	**9%**	**6%**	**3%**	**3%**	**3%**	**3%**

Baseline | Cost increase | Endline | Cost decrease

Interpretation

- Applying **5MT/ha** of compost produced from on-farm organic material and off-farm manure can **reduce synthetic fertilizer** use by up to **30%**

- Incremental cost to purchase cow/poultry **manure** for compost and **cover crop seeds**
- **10% reduction in insecticides** applied due to soil protection offered and natural enemies attracted **cover cropping**

- Moderate labor cost increase, primarily from labor associated with **compost** production and application

- ~90% upfront investment for **machinery for compost production** (tractor and compost turner) shared across four farms
- ~10% upfront investment for planting **windbreaks** around coffee plot (e.g., mahogany)

[1]We have chosen to include upfront investments in the cost calculation to provide a more accurate reflection of the true economic burden required for investing in regenerative practices

Assumptions: Constant prices, constant input costs, constant exchange rate, and no inflation

Sources: TechnoServe analysis & expert interviews

E With an already high baseline, productivity improvements remain modest. A viable business model for establishing on-farm composting is crucial

IMPACT FROM CLIMATE SHOCKS NOT REFLECTED

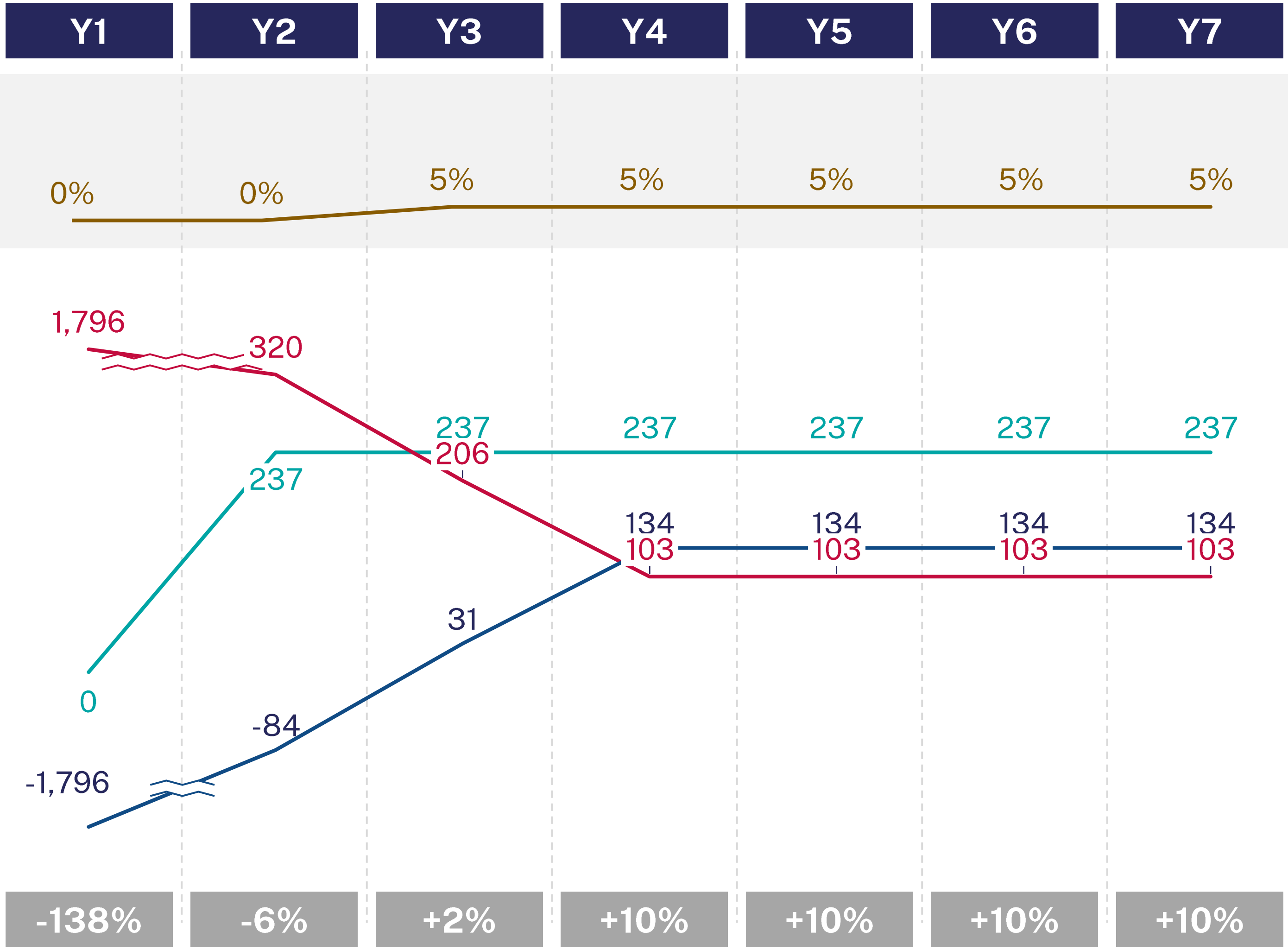
Impact on yield
% change vs. baseline

Baseline yield = 1,601 kg/ha

Impact on revenue, costs, and profit
$ change vs. baseline per hectare

— Incremental revenue
— Incremental costs
— Incremental profit

Total profit
% change vs. baseline
Baseline profit = $1,298/ha



Interpretation

Slight productivity gains from N-fixing **soil cover**

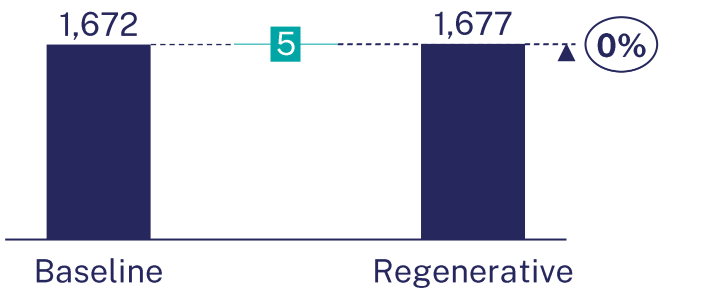
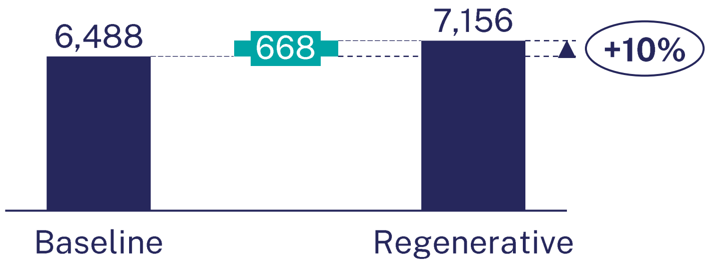
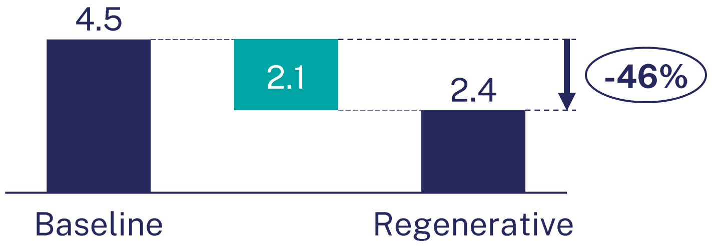
- Increased productivity from **soil health** improvements drive revenue gain

- Incremental costs driven by **organic inputs,** offset by savings in synthetics

- **Compost machinery investments** yield insufficient economic returns for individual farmers. Viable implementation requires either scaled business models or carbon offset subsidies to bridge the financial gap.

Assumptions: Constant prices, constant input costs, constant exchange rate, and no inflation. Does not include the potential impact of shocks over the transition period and/or increased resilience of regenerative farms in the face of those shocks
Sources: TechnoServe analysis & expert interviews

D E Scaling these farm-level impacts to all small-scale Arabica farms represents an opportunity to mitigate 1.6 million MT CO_2e annually, across 480k hectares

	Change unlocked by first phase regenerative transition	**Size of opportunity** (at 50% adoption rate)	Annual impact at steady state
ECONOMY *Exports*	'000 MT of GBE 	$3,458 / MT GBE FOB price	**$16 Million additional Arabica coffee exports per year[1]**
PEOPLE *Farmer Income*	$ per farm 	96K farms within archetype[2]	**$64 Million additional farm income per year**
NATURE *GHG Emissions*	MT CO_2e/MT GBE 	804K MT GBE produced by archetype[2]	**1.6M MT CO_2e mitigated per year**

[1]Assumes all incremental production from farms that adopt selected regenerative practices is absorbed by export markets [2]Assumes 50% of archetype adopts regenerative practices
See appendix for all calculation inputs and assumptions

F Bridging the funding gap for upfront investment in composting machinery is the most critical factor to materialize this roadmap

	Purpose of investments	Investment needed over 7-year transition[1] Per Farm	Total for archetype	Share of total
Upfront transition investment	**Investment in machinery for compost production** (tractor and compost turner)[2]. Relatively minor investment to **plant windbreaks** around coffee plot (e.g., mahogany)	$6,223	**$595M**	**55%**
Transition operating expenses	Covering increased **organic inputs, intercropping and associated labor costs**	$2,707	**$259M**	**24%**
Foregone net income due to initial yield drop	None needed given there is no drop in productivity	n.a.	n.a.	0%
Technical assistance	**Technical support** to educate and guide farmers on soil conservation, cover cropping, and INM adoption, including **on-farm demonstration plots**	$2,395	**$229M**	**21%**
TOTAL INVESTMENT		$11,325 per farm	**$1,083 Million**	

Existing finance or technical assistance provided by industry, civil society or public sector entities could be directed towards these efforts

[1]Sum of investments needed over a 7-year transition period. Assumes 50% of archetype adopts regenerative practices. [1]Assumes large-scale equipment can be right-sized to small-scale farms in this archetype, and/or business models that generate economies of scale
See appendix for all calculation inputs and assumptions

Regen practices–primarily composting–can unlock almost 50% reduction in Brazil's GHG emissions from Arabica production

Farm archetype focus of study
- **~190k small Arabica farms (<10ha);** ~91% of total Arabica farms
- **High mechanization; high input use; full-sun**

Regenerative opportunities:
- **Farms are highly productive** (1,600 kg GBE / ha), but are monocultures with **low biodiversity and low soil organic matter**
- Farmers can achieve higher incomes and reduce GHG emissions through implementation of the following practices:
  - **Soil conservation and cover cropping:** Increase yield and improve soil health by providing soil cover, reducing weed pressure, and attract natural enemies of coffee pests
  - **Integrated nutrient mgmt.**: Correct nutrient application with reduced synthetic inputs and additional organic inputs

Environmental benefits:
- Priority regenerative practices can **reduce GHG footprint by 46%**, from 4.5 to 2.4 kg CO2e / kg GBE, primarily through reduction in fertilizer emissions and improved residue management through composting activities
- Prioritized practices also contribute to biodiversity through environments created by cover cropping and windbreaks and soil health through agrochemical reduction and increase in organic matter applied to soil

Economic benefits:
- Regenerative practices can improve **farm profitability** from **~$1,298/ha to ~$1,431/ha** (10%) by year four, largely through a 5% increase in productivity from N-fixing soil cover. **However, upfront investment in compost machinery yields insufficient economic returns for individual farmers. Viable implementation requires either scaled business models or carbon offset subsidies to bridge the financial gap.**
- In addition to profitability improvements, adopting prioritized practices will reduce farmer exposure to volatility in chemical inputs costs and establish a foundation for improving farm resilience via additional follow-on practices

Investment required:
- **A blended finance approach that covers ~$9,000 in transition capital and ~$2,400 in technical assistance per farm** is fundamental to enable farmers to embark in this journey.

EXPECTED BENEFITS

96k farms

478k hectares

ECONOMY
- **<1%** increase in Arabica exports[2]
- **$16M** additional exports p.a.

PEOPLE
- **10%** increase in farm income[3]
- **$64M** additional farm income p.a.

NATURE
- **46%** reduction in kg CO_2e/kg GBE[4]
- **1.6M MT** CO_2e abated p.a.

$155 Million investment p.a. over 7 years[1]

[1]Sum of investments needed over a 7-year transition period; [2] Assumes all incremental production is absorbed by export markets; [3]Farmer net income at steady state versus baseline for farms that adopt selected regenerative practices, assumed as 50% of all farms in the archetype [4] Variance in GHG emissions for coffee produced by adopting farms, based on Cool Farm Platform.
See appendix for all calculation inputs and assumptions

Appendix 1
REGENERATIVE COFFEE FARMING FRAMEWORK

Rito Girón Hernández (right) learns techniques to improve his coffee production in the department of Intibucá, Honduras. (TechnoServe / Olivia Sakai)

Ten Pillars of Regenerative Agriculture for Coffee Farming

1 Renovation, Rehabilitation, and Coffee Varieties

Rejuvenating aging and replacing diseased/ poorly managed coffee trees with new trees or improved coffee varieties capable of producing higher yields and/or better qualities

- Pruning
- Rejuvenation, including stumping
- Grafting (in nurseries or topworking for adult plants)
- Replanting old/diseased coffee trees
- Use of improved varieties
- Variety diversification

2 Agroforestry Systems and Shade

Growing trees, coffee plants, and other crops within the same plot (intercropped and around edges), creating multiple vegetation layers similar to a natural forest

- Shade management
- Shade tree species diversity

3 Soil Conservation and Cover Cropping

Activities that protect topsoil against water and wind erosion, as well as improve soil health and water retention

- Cover cropping[1]
- Intercropping[2]
- Physical structures (such as live and dead barriers, terraces, living fences, windbreaks)
- Contour planting
- Minimizing soil disturbance

4 Integrated Weed Management (IWM)

Preventative and corrective measures that limit weed introduction and spread, help coffee outcompete undesirable weeds, and prevent weeds from adapting to management measures

- Mulching with organic residue
- Physical control of weeds (such as trimming, mowing, slashing, uprooting)
- Spot chemical applications on aggressive weeds

5 Integrated Pest & Disease Management (IPDM)

A pest and disease management strategy based on regular monitoring and the timely application of nature-based prevention and control measures

- P&D identification and monitoring
- Field hygiene practices (such as removal of diseased parts, sanitation of farm tools, timely harvesting and disposal of fallen cherries)
- Biological control (such as biocontrol agents, biopesticides, insects)
- Traps
- Precision applications of selective pesticides

[1] Focus on service crops.
[2] Focus on ground crops grown for income or consumption purposes.

Ten Pillars of Regenerative Agriculture for Coffee Farming (2/2)

6 Integrated Nutrient Management (INM)

The efficient and balanced use of mineral fertilizers, along with the management of organic resources to ensure optimal crop nutrition, sustain soil health, and minimize negative environmental impacts

- Soil analysis and field observation
- Soil amendments (e.g., lime)
- Composting and vermi-composting
- Optimal fertilizer[3] management (4R strategy)
- Application of biofertilizers and/or beneficial microorganisms

7 Efficient Water Use

Minimizing production and post-harvest water footprint by reducing use and loss of water, promoting water recycling, and avoiding contamination of water sources

- Rainwater harvesting (such as reservoirs or collection basins)
- Improved irrigation management (efficient systems, water quality, maintenance)
- Efficient water use in postharvest processing (such as water recycling/ recirculation systems, dry fermentation tanks, special milling machines, honeys/ naturals)

8 Wastewater Management

Actions to limit or eliminate the negative effects of residual water from postharvest processing on natural resources and human health, and reduce the carbon footprint of coffee production

- Wastewater treatment (such as lime, biodigesters, oxidation tanks, ecomills, vetiver grass)

9 Waterbody Protection[1]

Actions to limit or eliminate the contamination waterbodies that are on or near coffee farms

- Riparian buffers of natural vegetation

10 Waste Valorization and Production of Organic Inputs[2]

Recycling and converting organic waste and crop residues into products that can be used on the coffee farm, thereby reducing the need for external inputs

- Biochar production
- Anaerobic digestion of wastewater

[1] CIAT's Landscape Action practice includes waterbody protection with riparian barriers among other practices that are beyond an individual farmer's control. Protecting waterbodies on or near coffee farms with buffer zones is a feasible practice for most archetypes and is included in other regenerative agriculture assessment frameworks.
[2] Other waste valorization sub-practices mentioned by CIAT include animal feed that includes coffee pulp, compressed husk pellet production, mushroom production, and insect cultivation. These sub-practices have been removed from the Framework because they are not common strategies and not relevant across most archetypes
[3] Includes both organic and synthetic fertilizers

Beyond GHG, these 10 regenerative pillars deliver significant environmental benefits across soil health, water conservation and quality, and biodiversity and land use

Impact area(s)

	Pillars	Soil Health	Water Conservation and Quality	Biodiversity and Land Use
1	Renovation, Rehabilitation, and Coffee Varieties	• **Cover soil and prevent erosion** with pruned materials	• **Minimize risk of water pollution** with reduced fungicide and insecticide use[2]	• **Allow for more efficient use of available land**, reducing pressure on remaining forest
2	Agroforestry	• **Protect soil** against water and wind erosion • **Enhance soil life**, fertility, and nutrient cycling	• **Improve water regulation and retention** ("hydraulic lift" and "nutrient pump" effects)	• **Provide habitats** for insects, plants, birds, soil fauna, and microbes with tree canopies and litter
3	Soil Conservation and Cover Cropping	• **Reduce loss of fertile topsoil** • **Improve soil temperature**, aeration, porosity	• **Improve water infiltration and retention**	• **Provide habitats** for functional biodiversity with cover crops
4	Integrated Weed Management (IWM)	• **Help control soil erosion and runoff** with mulching cover	• **Minimize risk of contamination of water bodies** with reduced use of herbicides[1] • **Improve water infiltration** with mulching cover	• **Support functional biodiversity** (pollinators and natural enemies of pests) with reduced use of herbicides[1]
5	Integrated Pest & Disease Management (IPDM)	• **Increase soil biodiversity** with reduced use of harmful insecticides and fungicides[1]	• **Minimize risk of contamination of surface and groundwater** with reduced use of insecticides and fungicides[1]	• **Support functional biodiversity** (pollinators and natural enemies of pests) with reduced use of insecticides and fungicides[1]

Approx. level of impact: Very high High Medium Low

[1] Impact level vary per archetype depending on level of synthetic input use; 2Impact area only relevant for archetypes with irrigation and/or wet milling
Sources: CIAT (2023), TechnoServe analysis & expert interviews

Beyond GHG, these 10 regenerative pillars deliver significant environmental benefits across soil health, water conservation and quality, and biodiversity and land use (2/2)

Impact area(s)

Pillars	Soil Health		Water Conservation and Quality		Biodiversity and Land Use	
6 Integrated Nutrient Management (INM)	High	• **Stimulate nutrient cycling and retention** with combined use of mineral fertilizers, organic resources and soil amendments[1] • **Strengthen soil carbon stocks** with organic inputs	High	• **Reduce nutrient losses from volatilization and leaching**, thus reducing contamination of water bodies with excess nutrients • **Enhance soil water retention** with improvements in organic resource management	Low	• **Support soil microbial diversity** with a balanced and nutrient-rich soil environment • **Help to protect wild biodiversity on farm and in the surrounding landscape** with reduced eutrophication and chemical dependency[1]
7 Efficient Water Use	Low	• **Help limit GHG emissions from postharvest wastewater** with reduced water consumption[2]	Very high	• **Prevent aquifer depletion and secure water availability in watersheds**	Very high	• **Help protect and restore wild biodiversity** with conservation of water sources
8 Wastewater Management	Low	• **Improve soil** health with reuse of byproducts from coffee processing as compost[2]	Very high	• **Protect water resources** from overuse and contamination	High	• **Help conserve aquatic life**
9 Waterbody Protection	Medium	• **Support control of soil erosion and landslides**	Very high	• **Decrease sedimentation and contamination of water bodies**	High	• **Enhance biodiversity** with improved aquatic habitats
10 Waste Valorization and Production of Organic Inputs	High	• **Replenish soil** with essential nutrients • **Enhance nutrient cycling** with source of energy for soil biota	Medium	• **Help prevent watershed contamination** from untreated wastewater[2]	High	• **Help protect and restore wild biodiversity** with reduced negative effects of unprocessed coffee waste disposal

Approx. level of impact: Very high, High, Medium, Low

[1]Impact level vary per archetype depending on level of synthetic input use.
[2]Impact area only relevant for archetypes with irrigation and/or wet milling.
Sources: CIAT (2023), TechnoServe analysis & expert interviews

Appendix 2

ADDITIONAL DETAILS ON METHODOLOGY

From right: Vicky Tarime and Gadi Swai prepare coffee beans for drying in the foothills of Mt Kilimanjaro, Tanzania. (TechnoServe / Naashon Zalk)

Roadmaps for each country identify proven practices relevant to the local context, that benefit both farmer incomes and nature

APPROACH TO DESIGN THE REGENERATIVE TRANSITION

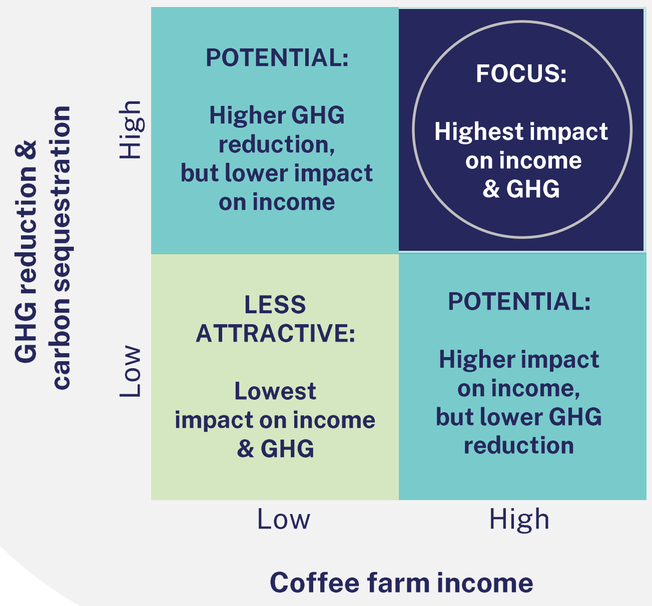
- The ambitious outcomes described in the roadmaps are generated by envisaging a world where farmers in major coffee growing countries adopt a subset of practices from the Regenerative Coffee Farming Framework.

- Practices are selected for each coffee origin based on assessment of relative impact on the environment and coffee farm income. To shortlist practices that can immediately attract investment at scale, GHG mitigation is used as the primary environmental screen and income from coffee and agroforestry are used as the primary source of farm revenue.

- However, these practices also offer substantial benefits for soil health, water use, and biodiversity, which the report describes qualitatively. A future phase of this study would incorporate the costs and benefits of the full transition to regenerative coffee farming, including potential farm income from ecosystem services.

- Additionally, the study focuses on practices that are already being employed and have an evidence base for impact. While additional innovation may be required, scaling existing technologies already offers huge potential, as demonstrated in the quantified impact figures.

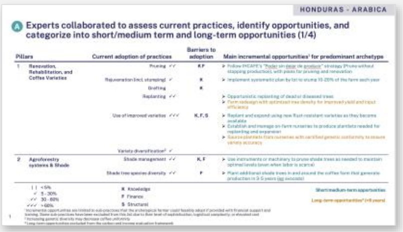
GHG & farm income framework
Based on expected incremental impact



Farm-level economic and GHG modeling supports each country roadmap. Resilience, soil, water, and biodiversity impacts are captured qualitatively

GHG EMISSIONS AND FARM INCOME EVALUATION METHODOLOGY

A Establish base practices and identify opportunities

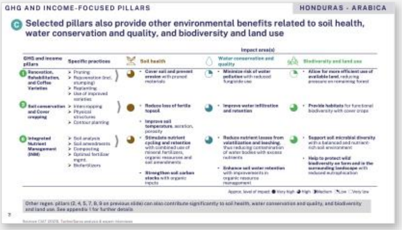


- Document evidence of climate change impact on coffee
- Identify dominant coffee farm archetypes based on size, mechanization
- Assess existing farming practices
- Identify and categorize regenerative opportunities across short vs long term

B Shortlist practices for GHG and farm income

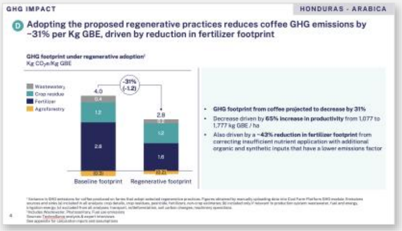
- Evaluate regenerative practices based on feasibility, economic viability, and adoption potential
- Rank practices by impact on GHG reduction, carbon sequestration, farm income

C Assess impact on soil, water, and biodiversity



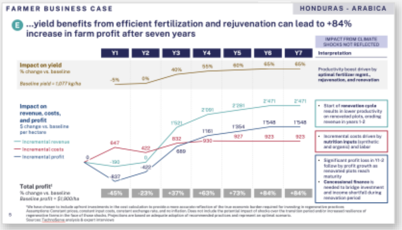
- Qualitatively analyze impact on soil health from increased organic matter
- Evaluate water conservation benefits in retention, runoff, and quality changes
- Assess impacts on efficiency of land use, species diversity and habitat restoration

D Quantify impact on GHG emissions



- Collect farm-level data on synthetic fertilizer use, organic inputs, and emissions
- Model emissions reductions using Cool Farm Platform

E Quantify change in farmer income



- Gather farm data on yields, input and labor costs, and selling prices
- Calculate year by year impact on revenues and costs from new practices
- Forecast long-term profitability shifts

F Estimate investment and incremental costs

- Calculate farmer capital to cover incremental costs, and foregone net income during each transition year
- Estimate costs of technical support to farmers
- Define types of capital required to meet needs

See appendix for additional details on methodology. Individual country reports available with detailed analysis and commentary.

- **Data collection:** Aggregate and anonymize data from TechnoServe farm surveys, partners' farm-level data (i.e., Nestle, JDE Peet's), public research, and expert interviews.
- **Data analysis:** Filter raw datasets received to include only those farms that fit the selected archetype dimensions (e.g., farm size, mechanization, input use, irrigation).
- **Key assumptions:** Constant prices, constant input costs, constant exchange rate, and no inflation. Does not include the cost of inaction, or the potential impact of shocks over the transition period and/or increased resilience of regenerative farms in the face of those shocks. Projections are based on adequate adoption of recommended practices and represent an optimal scenario.
- **Interpretation and recommendations:** Consult with coffee agronomists, practitioners and subject matter experts to validate insights from data analysis, align on selection of practices for GHG and income modeling, provide quantitative inputs to project change in drivers of GHG emissions, yields and costs, and provide qualitative perspectives on impact on soil, water and biodiversity.

GHG emissions were obtained for each country archetype, using the online-based calculating tool Cool Farm Platform

Methodology

- **Data collection:** Data was collected from TNS farm field surveys, partners' farmer data, public research, and expert interviews. All data has been anonymized for confidentiality purposes
- **Data analysis technique:** Raw datasets received were aggregated and filtered to include only those farms that fit the selected archetype dimensions.
- **Calculating tool (and methodology):** GHG emissions were obtained by manually uploading data into Cool Farm Platform's (CFP) GHG module, version Methods 2.2.0 - CFP 2.XX. The pathway used was "perennials", and the typology selected was "Coffee – shaded" for all archetypes except for Brazil Arabica and Brazil Robusta, for which "Coffee – monocrop" was selected

- **Global Warming Potential (GWP):** IPCC AR6
- **Operational boundary:** GHG emissions assessment limited to on-farm emissions from activities that farmers have direct control over and could be mitigated with implementation of regenerative practices. Explanations of emissions sources/sinks excluded are found in upcoming slides. This study assesses the potential variance in GHG emissions from adopting certain regenerative practices, rather than coffee's carbon footprint. A complete carbon footprint would require a life-cycle assessment, either cradle-to-gate or cradle-to-grave, which exceeds the purposes of this study

Emissions sources/sinks considered:

Included in all analyses:

- Crop details
- Crop residues
- Pesticide
- Fertilizers
- Non-crop estimates

Included in some analyses:

- Wastewater[1]
- Fuel and energy[2]
- Irrigation energy[3]

Excluded from all analyses:

- Transport
- Re/deforestation
- Soil carbon changes
- Machinery operations

[1] Only included if farmer archetype irrigates and/or wet process on-farm; 2Only included if farmer archetype is highly mechanized; 3Only included if farmer archetype irrigates

Certain emission sources and sinks were excluded from the study as they were out-of-scope, not applicable to the farmer archetype, or redundant

Emission sources/sinks excluded

Source/Sink	Archetype	Reason for exclusion
Inbound transportation	All archetypes	Assessment focuses only on on-farm emissions that could be mitigated with implementation of regenerative practices. All upstream emissions, except for fertilizer and phytosanitary input manufacturing, are out-of-scope
Outbound transportation	All archetypes	Assessment focuses only on on-farm emissions that could be mitigated with implementation of regenerative practices.. All downstream emissions beyond the farm-gate are out-of-scope
Land-use change (LUC)	All archetypes	Assessment focuses only on on-farm emissions that could be mitigated with implementation of regenerative practices.. Emissions from any land use change that may have occurred prior to intervention cannot be changed with regenerative transition and are therefore out-of-scope
Soil organic carbon (SOC)	All archetypes	Land management practices such as carbon inputs or tillage are considered irrelevant in the tier 1 SOC model for perennial systems, as indicated by IPCC [2019] (Volume 4, Figure 5.1). Consequently, only LUC impacts the SOC model at present
De/Reforestation	All archetypes	Assessment focuses only on on-farm emissions that could be mitigated with implementation of regenerative practices. Emissions from any deforestation that may have occurred prior to intervention cannot be changed with regenerative transition and are therefore out-of-scope
Machinery operations	All archetypes	Fallback for when accurate energy usage is not available. Given availability of primary energy usage data, machinery operations excluded.
Wastewater	Only if archetype doesn't wash coffee on farm	Not applicable for farmer archetypes that do not wash coffee on-farm
Energy for irrigation	Only if archetype doesn't use artificial irrigation	Not applicable for farmer archetypes that do not artificially irrigate their fields
Fuel and energy use	Only if archetype isn't highly mechanized	Not applicable for farmer archetypes that are not mechanized, and heavily rely on manual labor

Workarounds were implemented to address current limitations within the Cool Farm Platform, which is still in development

Tool & methodology limitations

Source/Sink affected	Limitation	Analysis workaround
Organic fertilizers	Only a few options are available for organic fertilizers. Although CFP allows to enter a fertilizer's NPK composition to estimate manufacturing emissions of products that are not already mapped, it can only be used for synthetic inputs	Organic fertilizers included in calculations only if suitable match based on carbon sequestration potential input from CFP options available
Non-NPK fertilizers (micronutrients)	If a non-NPK fertilizers is not already mapped in CFP, it cannot be assessed through the option "compose your own NPK"	Excluded from carbon footprint analysis
Bio-pesticides	Although there are emissions associated to the manufacturing of bio-pesticides, CFP is not built to consider them	Excluded from carbon footprint analysis
Inputs' density (liters/kilograms)	Emission factors for fertilizers and pesticides are defined per kilogram of product used. There are no emission factors defined per liters of product used	In cases where quantity of input used was provided in liters, density liters/kilograms was assumed to be equal to 1. This is in line with CFP's approach
Crop residues	Emissions factors for management options are still in development (e.g., "residues left on soil" mgmt. option is not yet modelled); Refined emissions factors will be part of the *L*SOC-N2O model coming in 2025	Calculated using Cool Farm Tool (with 0% waste fruit included due to negligible amounts of coffee cherries left on farm and pulp residues included only for archetypes with dry hulling or wet milling)
Soil organic carbon (SOC)	Land management practices such as carbon inputs or tillage are considered irrelevant in the tier 1 SOC model for perennial systems, as indicated by IPCC [2019] (Volume 4, Figure 5.1). Consequently, these type of practices do not impact CFP's SOC model at present	Excluded from carbon footprint analysis
Intercrops, shade-trees and hedges	CFP assess carbon sequestration from these type of biomass based on the plant's specie. However, it offers a limited number of species to choose from, oftentimes, not in line with region or farmer context	• Shade trees included in calculations only if suitable match based on carbon sequestration potential input from CFP options available (incl. tropical shade tree in dry areas, tropical shade trees in wet areas – canopy trees, tropical shade trees in wet areas – understory, temperate conifers, temperate broadleaf trees, temperate shrubs) • Intercrops included in calculations only if suitable match based on carbon sequestration potential input from CFP options available (incl. avocado, cashew, jackfruit, rubber durian)

Assumptions used to scale up farm-level model to all farms in archetype, to arrive at total benefits and investment required

	Value	Commentary
Regenerative adoption rate of farms in each archetype	50%	Assumed universal adoption rate across countries based on TechnoServe estimates
Transition financing per farm	Country-specific	Assumed financing is provided to farms to maintain at least their baseline income throughout the regenerative transition Ex: If a farm's baseline income is $100, and in year 1 of the regenerative transition income drops by $25 to $75 (due to a $10 revenue loss from one practice and $15 in additional operating expenses), the transition cost per farm is broken down as $15 in operating expenses and $10 in foregone revenue, making up the total needed to reach the $100 baseline income. In year 2, if income rises to $120, exceeding the $100 baseline, no transition financing is provided
Technical assistance cost per farm	Country-specific	Assumed all farmers who adopt regenerative practices receive full technical assistance package, and farmers who do not adopt regenerative practices drop out in Y1, incurring only 10% of total technical assistance costs Technical assistance assumed to be greater in the first 2 years and only light touch in the following 5 years Technical assistance includes demonstration plots across 5% of farms, assuming cost per plot equal to the transition financing provided per farm plus 10% for admin. activities

Appendix 3
BRAZIL ARABICA DETAILED ANALYSES

Coffee grows under the shade of plantain trees in Honduras. (TechnoServe / Olivia Sakai)

A This business case analysis is focused on high input use, full-sun Arabica coffee farms under 10 hectares; representing ~190k Arabica farms

	Dimension	Options	Brazil - Arabica
Farmer Archetype	**Coffee species**	Arabica Robusta	Arabica
	Coffee farm size	Small (<10ha) Medium (10-100ha) Large (>100ha)	Small (<10ha)
	Predominance of archetype	Number of farms (as % of total)	91%[1]
Relevant descriptors associated with this archetype	**Mechanization**	Low Medium High	High
	Input use (synthetic fertilizer and crop protection products)	Low Medium High	High
	Water source	Rain-fed Irrigation	Rain-fed
	Shade	Full-sun Shade-grown with low species diversity Shade-grown with high species diversity	Full-sun
	Processing on farm	Wet milling Dry hulling Drying (no hulling) None	Dry hulling

[1] IDH (2014), GCP (2017), Enveritas (2018)

A Experts collaborated to assess current practices, identify opportunities, and categorize into short/medium term and long-term opportunities (1/3)

Pillars		Current adoption of practices		Barriers to adoption	Main incremental opportunities[1] for predominant archetype
1	Renovation, Rehabilitation, and Coffee Varieties	Pruning	✓✓✓		
		Rejuvenation (incl stumping)	✓✓	K, F	➢ Establish a long-term (>10 years) rejuvenation plan to maintain optimal yield
		Grafting	N/A	K, F, S	
		Replanting	N/A		
		Use of improved varieties	✓✓✓	K	➢ Adopt existing varieties that are resistant to local pest and diseases
		Variety diversification[2]	✓		
2	Agroforestry systems & Shade	Shade management		K, F	➢ Individualized planning. E.g.: shade tree rows, like avocado, every 10 rows of coffee that provide other benefits such as income diversification and natural barriers
		Shade tree species diversity			
3	Soil conservation and Cover cropping	Cover cropping[3]	✓	K, F	➢ Plant cover crops that fixate nitrogen, attract natural enemies, and/or increase organic matter (e.g.: brachiaria, buckwheat, forage radish)
		Physical structures	✓	K, F	➢ Implement crops as physical structures (windbreaks) such as wood (mogno), that can attract natural enemies (inga) or diversify income (banana)
		Intercropping[4]	✓		➢ Intercrop with crops such as beans on younger coffee
		Contour planting	✓	F	
		Minimizing soil disturbance	✓		

( ) < 5%
✓ 5 - 30%
✓✓ 30 - 60%
✓✓✓ > 60%

K Knowledge
F Finance
S Structural

Short/medium-term opportunities

Long-term opportunities[5] (>8 years)

[1] Incremental opportunities are limited to sub-practices that the archetypical farmer could feasibly adopt if provided with financial support and training. Some sub-practices have been excluded from this list due to their level of sophistication, logistical complexity, or elevated cost;
[2] Increasing genetic diversity may decrease coffee uniformity; [3] Focus on service crops; [4] Focus on ground crops grown for income or consumption purposes
[5] Long-term opportunities excluded from the GHG and income evaluation framework

A Experts collaborated to assess current practices, identify opportunities, and categorize into short/medium term and long-term opportunities (2/3)

Pillars		Current adoption of practices		Barriers to adoption	Main incremental opportunities for predominant archetype
4	Integrated Weed Management (IWM)	Mulching w/ organic residue	✓✓	K	➢ Improve mulching by combining inputs from the coffee farm and neighboring farms
		Physical control of weeds	✓✓	F	➢ Use weeding instruments that don't damage the soil (e.g.: mechanical trimmer, ecological brush cutter)
		Spot chemical applications	✓	K	➢ Decrease the amount of herbicide applied by applying it only to harmful and aggressive weeds
5	Integrated Pest & Disease Management (IPDM)	P&D identification & monitoring	✓✓	K, F	
		Field hygiene practices	✓✓✓	S	
		Biological control	✓	K, F, S	➢ Increase adoption of biologicals and promote new biologicals use
		Traps			
		Precision application of selective pesticides	✓✓✓	K	➢ Establish a pest pressure monitoring system to enable more targeted responses to pest outbreaks

( )	< 5%
✓	5 - 30%
✓✓	30 - 60%
✓✓✓	> 60%

K Knowledge
F Finance
S Structural

Short/medium-term opportunities

Long-term opportunities[1] (>8 years)

[1] Long-term opportunities excluded from the GHG and income evaluation framework

A Experts collaborated to assess current practices, identify opportunities, and categorize into short/medium term and long-term opportunities (3/3)

Pillars		Current adoption of practices		Barriers to adoption	Main incremental opportunities for predominant archetype
6	Integrated Nutrient Management (INM)	Soil analysis & field observation	✓✓	K	➢ Adopt advanced soil testing that includes soil health, organic matter, and soil structure analysis to inform nutrition plan
		Soil amendments	✓✓	K	➢ Implement basic soil amendments inputs accordingly to results of soil analysis
		Composting & vermi-composting	✓	K, F, S	➢ Implement composting, apply organic minerals and other organic fertilizers by using inputs from the farm or from local farms
		Optimal fertilizer mgmt. (4R strategy)	✓✓✓		
		Biofertilizers/ microorganisms	✓	K, F	➢ Build fermentation tanks to produce own biofertilizers
7	Efficient Water Use	Rainwater harvesting		F, S	
		Improved irrigation management	N/A		*Not applicable to farmer archetype (relies on rain-fed system for water source)*
		Efficient water use in post-harvest processing	N/A		*Not applicable to farmer archetype (no wastewater generated from dry hulling)*
8	Wastewater Management	Wastewater treatment	N/A		*Not applicable to farmer archetype (no wastewater generated from dry hulling)*
9	Waterbody Protection	Riparian buffers	✓✓✓		*No opportunities included due to high existing rates of adoption*
10	Waste valorization & Production of organic inputs	Biochar production		K, F, S	➢ Increase biochar production by making it available to smallholders (e.g.: partner with industries)
		Anaerobic digestion of wastewater	N/A		

( ) < 5%
✓ 5 - 30%
✓✓ 30 - 60%
✓✓✓ > 60%

K Knowledge
F Finance
S Structural

Short/medium-term opportunities

Long-term opportunities[1] (>8 years)

[1] Long-term opportunities excluded from the GHG and income evaluation framework

B Short & medium-term incremental opportunities were prioritized for quantitative analysis based on expected impact on GHG mitigation and farmer income (1/2)

	Pillars	Short & medium-term incremental opportunities	GHG impact areas	Income impact areas
1	Renovation, Rehabilitation, and Coffee Varieties	➢ Establish long-term (>10 years) rejuvenation plans tailored to individual farms[1] ➢ Adopt existing varieties that are resistant to local pest and diseases	• Reduce fungicide use	• Reduce costs of production • Improve farm resilience to shocks
2	Agroforestry systems and Shade	➢ Individualized planning. E.g.: shade tree rows, like avocado, every 10 rows of coffee	• Increase tree biomass • Reduce insecticide use	• Diversify income • Improve farm resilience to shocks
3	Soil conservation and Cover cropping	➢ Plant cover crops that fixate nitrogen, attract natural enemies, and/or increase organic matter (e.g.: brachiaria, buckwheat, forage radish) ➢ Intercrop with crops when coffee is younger ➢ Implement crops as physical structures that can attract natural enemies or diversify income	• Optimize yield • Reduce quantity of synthetic fertilizer • Reduce insecticide use	• Increase coffee production • Reduce costs of production • Diversify income • Improve farm resilience to shocks
4	Integrated Weed Management (IWM)	➢ Improve mulching by combining inputs from the coffee farm and neighboring farms ➢ Use weeding instruments that don't damage the soil (e.g.: mechanical trimmer, ecological brush cutter) ➢ Decrease the amount of herbicide applied by applying it only to harmful and aggressive weeds	• Reduce herbicide use • Improve crop residue & waste mgmt.	• Reduce costs of production • Improve farm resilience to shocks
5	Integrated Pest & Disease Management (IPDM)	➢ Increase adoption of biologicals and promote new biologicals use ➢ Establish a pest pressure monitoring system to enable more targeted responses to pest outbreaks	• Reduce insecticide use	• Reduce costs of production • Improve farm resilience to shocks

☐ GHG & Income-focused practice pillars included in GHG and farmer business case analysis

[1]Not opportunity for yield improvement due to already high adoption

B Short & medium-term incremental opportunities were prioritized for quantitative analysis based on expected impact on GHG mitigation and farmer income (2/2)

Pillars		Short & medium-term incremental opportunities	GHG impact areas	Income impact areas
6	Integrated Nutrient Management (INM)	➢ Interpret soil analysis and plan farm's activities accordingly ➢ Implement basic soil amendments inputs accordingly to results of soil analysis ➢ Implement composting, apply organic minerals and other organic fertilizers by using inputs from the farm or from local farms	• Optimize yield • Reduce quantity of synthetic fertilizer • Improve crop residue & waste mgmt.	• Increase coffee production • Improve farm resilience to shocks
7	Efficient Water Use	*Not applicable to farmer archetype*	–	–
8	Wastewater Management	*Not applicable to farmer archetype*	–	–
9	Waterbody Protection	*No opportunities identified*	–	–
10	Waste valorization & Production of organic inputs	*No opportunities identified*	–	–

GHG & Income-focused practice pillars included in GHG and farmer business case analysis

D Assumptions entered into Cool Farm Platform to estimate change in GHG emissions for selected farmer archetype

Data point	Unit	Value: Baseline	Value: Endline
Farmer data			
Latitude / longitude	°	-18.7/ -47.4	
Climate zone based on IPCC classification		Tropical moist	
Annual average temperature	°C	24	
Soil characteristic based on IPCC classification		High activity clay	
Crop details (per year)			
Soil type		Fine	
Coffee tree density	#/Ha	3,887	
Total fresh cherry yield	Kg	61,000	63,900
Fertilizer use (per year)			
Fertilizer type #1 / production region		Choose your own NPK[1] / Europe 2014	
Application rate	Kg/Ha	1,513	984
Fertilizer type #2 / production region			
Application rate	Kg/Ha		
Pesticide use (per year)			
Pesticide type #1 category / type		Post-emergence/ pesticide	
% of the field applied	%	100	
% active ingredients	%	50	
Application rate	L/ha	30.7	27.6

Data point	Unit	Value: Baseline	Value: Endline
Crop residues			
Management selection(s)		Left distributed on field	Removed non-forced aeration compost
% of the field pruned per year	%	20	20
Fuel and energy			
Energy source #1		Gas (by volume)	
Energy used	L	1,720	1,720
Category		Field	
Energy source # 2		Grid electricity (by energy)	
Energy used	kWh	1,153	1,153
Category		Facility (processing)	
Carbon sequestration			
Shade tree type		Tropical shade trees in wet areas – canopy	
% of the field occupied	%	100	
Shade tree density	#/Ha	0	20

[1] Fertilizer composition: 23% N, 4% P2O5, 19% K2O
Source: Partner and public data , Cool Farm Platform

E P&L assumptions applied to estimate change in farmer income for selected archetype

Data point	Unit	Value: Baseline	Value: Endline
Farmer data			
Average coffee farm size	Ha	5	5
Market data			
Farm-gate price	$/kg GBE	2.96	2.96
Yield			
Average coffee yield	Kg / Ha	1,601	1,681
Operating costs			
Synthetic fertilizer	$ / Ha	1,031	670
Cost per unit	$ / kg	0.7	0.7
Volume applied	Kg / Ha	1,513	984
Organic fertilizer	$ / Ha	0	300
Cost per unit	$ / kg	0.1	0.1
Volume applied	Kg / Ha	0	1,700[1]
Pesticides	$ / Ha	226	203
Herbicide	$ / Ha	143	143
Labor	$ / Ha	1,090	1,126
Processing	$ / Ha	188	188
Other production costs	$ / Ha	755	905

Data point	Unit	Value: Baseline	Value: Endline
Upfront investments			
Equipment[2]	$ / Ha	0	1,310
Other upfront investments	$ / Ha	0	0
Outputs			
Total coffee farm revenue	$/ha	4,731	4,967
Total operating costs	$/ha	3,433	3,536
Total upfront investments[2]	$/ha	0	1,310
Total operating profit	$/ha	1,298	1,431
Profit margin	%	27	29

[1]Other weight of 5MT/ha organic compost made of on farm organic material (e.g., coffee husk)
[2]Investments made in Year 1
Source: Partner and public data

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- Luan Alves, TechnoServe
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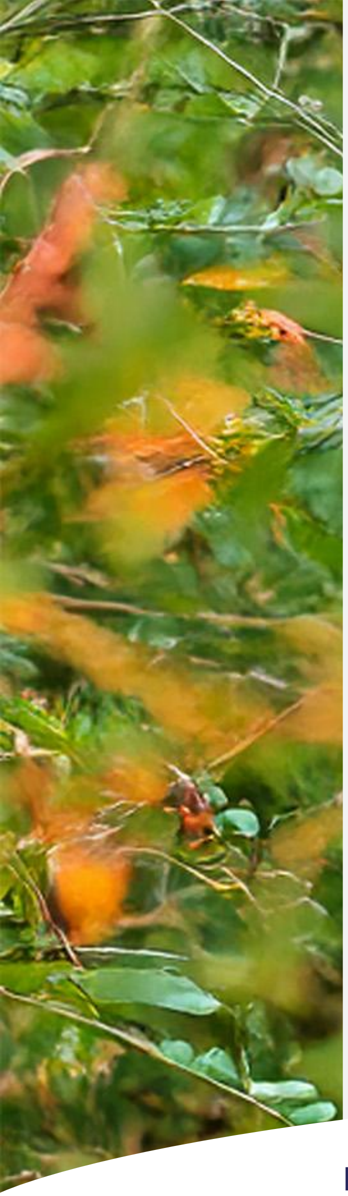

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