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FINAL REPORT

Impact Evaluation Feasibility Assessment of RESTORE

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Impact Evaluation Feasibility Assessment of RESTORE:

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Acronyms

ADS	Automated Directives System
AFOR	l'Agence Foncière Rurale
CDI	Côte d'Ivoire
CPR	Common-pool Resource
CSA	Climate Smart Agriculture
DID	Difference-in-Difference
eDNA	Environmental DNA
ET	Evaluation Team
FA	Feasibility Assessment
FC	Forestry Commission
FGD	Focus Group Discussion
GFW	Global Forest Watch
GHG	Greenhouse Gas
HEARTH	Health, Ecosystems, and Agriculture for Resilient Thriving Societies
HIA	Health Impact Assessment
IE	Impact Evaluation
INRM	Integrated Natural Resources Management
IP	Implementing Partner
IUCN	International Union for Conservation of Nature
KII	Key Informant Interview
LMB	Landscape Management Board
LQ	Learning Question
M&E	Monitoring and Evaluation
MDES	Minimum Detectable Effect Size
MDD-W	Minimum Diversity Diet for Women
MERL	Measurement, Evaluation, Research and Learning
NCS	Natural Climate Solutions
ofi	Olam Food Ingredients
PCR	Polymerase Chain Reaction
PE	Performance Evaluation
PES	Payment for Ecosystem Services
RA	Rainforest Alliance
RCT	Randomized Control Trial
REDD+	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries, and the Role of Conservation, Sustainable Management of Forests, and Enhancement of Forest Carbon Stocks in Developing Countries
RMSC	Resource Management Support Centre
SA	Strategic Approaches
SME	Small and Medium Enterprise
SU	Sampling Unit

SWPER	Survey-based Women's Empowerment Index
TOC	Theory of Change
USAID	United States Agency for International Development
USG	United States Government
VSLA	Village Savings and Loans Association

Executive Summary

OBJECTIVE AND SCOPE

The objective of this Feasibility Assessment (FA) is to assess the possible evaluation options for the United States Agency for International Development's (USAID) West Africa Resilient Ecosystem and Sustainable Transformation of Rural Economies (RESTORE) Activity in Ghana and Côte d'Ivoire (CDI).

The FA team considered the feasibility of an Impact Evaluation (IE) or Performance Evaluation (PE) for each of RESTORE's Strategic Approaches (SA), with a focus on both on-farm and off-farm biodiversity and conservation outcomes. In addition, USAID has asked the FA team to consider the implications of RESTORE for zoonotic outcomes and identify opportunities to contribute to the knowledge gap between reforestation efforts and zoonotic disease transmission, given the increased attention to the connection between ecological change and zoonotic disease transmission risk. The team assessed the data sources necessary for the measurement of outcomes related to zoonosis spillover risk.

IEs and PEs can both measure the causal impact of a program, or the difference in outcomes caused by an intervention or policy. When conducted properly, IEs can provide a high degree of statistical confidence in the ability to attribute program impacts to an intervention. Correspondingly, when implemented properly, rigorous counterfactual-based PEs can also provide useful, policy-relevant insight into program effects; they represent a means for rigorous longitudinal research, although causal attribution is not as strong as in the case of an IE. When combined, impact and performance methods provide a rich picture of what is working, why, and for whom. Addressing questions of 'why' by studying mechanisms, context, and implementation fidelity promotes an understanding of whether and why program theories hold and how to adapt interventions in other contexts.

The FA considers and recommends several design options, including IE and PE designs, which meet Agency-wide Health, Ecosystems, and Agriculture for Resilient Thriving Societies (HEARTH) and Mission learning interests, with the goal of determining the most rigorous options that can be applied given implementation, resource, and other constraints for this activity. The report provides USAID with design options and a full menu of available data sources to measure various options; among these methods, we put forward our recommendation to balance value and cost. Another purpose of the FA is to strengthen the program design in advance of field implementation to ensure the program is in the best possible position to achieve its desired impacts.

Given the phased approach to RESTORE's implementation plan, this FA will be designed through an incremental approach. During the first phase (August 2022 - January 2023), we assessed the viability of a rigorous evaluation for off-farm forest restoration, on-farm cocoa agroforestry, land and/or tree tenure, and alternative livelihoods activities. The implementing partners (IPs) are still working on finalizing the site selection for the off-farm forest restoration component, which is important for understanding overlap of on and off-farm activities and for developing a recommended evaluation design. A second stage of the design will occur following a scoping trip in May 2023, which coincides with the expected timeline for identification of off-farm site selection, allowing for finalization of IE design options.

Following the May 2023 scoping trip, we will finalize the evaluation approach and begin preparing for the baseline data collection. As per this report, we anticipate baseline data collection August - September 2023. In the 'Challenges' section below, we discuss the implications and challenges associated with completing baseline data collection after the planting season in June.

There are several important implications of this staggered approach. First, this FA report remains a 'living document' because we do not yet have all of the information necessary to finalize the design, and will not have all of that information until the end of May 2023 (the scoping trip and off-farm site selection).[1] Second, this FA report goes beyond a feasibility study and moves towards an 'Evaluation Design Document' due to the tight timeline of moving from final design to data collection.

RESTORE ACTIVITY OVERVIEW

The purpose of the RESTORE Activity is to demonstrate a scalable and regionally replicable model for community-led governance, natural resource management, and biodiversity conservation that aligns with regional and government priorities in cocoa production landscapes in the Guinean forests of Ghana and CDI. The RESTORE Activity works in partnership with a consortium of multinational chocolate companies, farmer cooperatives, and local partners led by Rainforest Alliance (RA) and Olam Food Ingredients (ofi) (formerly Olam International). It aims to establish the technical capacity, policy implementation approaches, and economic incentives to bring cocoa producing families, governments, and private sector actors together in a joint endeavor to secure improved livelihoods from cocoa farming, alongside increased tree cover and a scalable contribution to national and corporate emission reductions targets. The activity works at both farm and landscape scales, and seeks to support an inclusive landscape management governance body in selected target areas to drive resilient economic growth, with expanded opportunities for women and youth based on sustainable resource use.

RESTORE's specific objectives are:

- **Objective 1**: Increase tree cover on and off farm in the cocoa production landscapes.
- **Objective 2**: Enable effective and inclusive participatory governance for conserving forest and restoring degraded land in the landscapes.
- **Objective 3**: Build capacity and market incentives for farmers to apply climate-smart production practices and increase benefits from cocoa farming for women and young people.
- **Objective 4:** Facilitate economic diversification in cocoa farming communities, creating enabling conditions for economic and social empowerment of women and young people.

These objectives will be achieved by implementing a set of interventions in four landscapes in the Guinean forest (1 in Ghana and 3 in CDI).

[1] The ET team produced this FA report in May 2023, then updated the content based on information learned during the September 2023 Scoping trip.

RESTORE's SAs are as follows:

- **SA1**: Improve tree and/or land tenure processes and strengthen incentives for tree growing and conservation to restore tree cover and protect forest.
- **SA2**: Establish and strengthen the business and governance capacity of Landscape Management Boards (LMBs) and improve the conservation and natural resource management support that they provide to farmers.
- **SA3:** Increase use of climate-smart, more productive, regenerative, and sustainable cocoa production by improving farmers' capacities, knowledge, and resources.
- **SA4:** Promote and strengthen forest-friendly livelihood diversification through women- and youth-inclusive approaches that improve skills and access to funding, inputs, and markets.

SUMMARY OF FINDINGS

Based on current information, our FA finds that the interventions associated with on-farm components, including on-farm cocoa agroforestry, tenure security, and alternative livelihoods, are amenable to evaluation through rigorous PE methods – but not IE methods. In contrast, the 40 hectares of currently identified off-farm planting in Ghana will likely provide an opportunity for an IE of conservation and off-farm biodiversity options. The evaluation team (ET) team does not expect extensive ecological or biodiversity impacts from the boundary planting currently planned for the off-farm planting component in CDI. The ET team also does not expect that the current off-farm planting plans will have major zoonotic impacts. Considering the cost of collecting animal and human blood samples, the ET suggests the evaluation captures zoonotic transmission risks for diseases such as Malaria and Onchocerciasis through social surveys and ecological data measuring the prevalence of high risk carriers (e.g., mosquitos, bats), along with other health outcomes of relevance such as childhood stunting/wasting, and African swine fever.

In particular, RESTORE's **on-farm cocoa agroforestry** activities are not amenable to an IE because the assessment team was not able to identify a valid counterfactual group due to the saturation of similar initiatives on cocoa-farming landscapes in both countries. Instead, the ET team suggests using post-data collection statistical methods to account for the potential systematic differences between program and comparison groups. For the **tenure** intervention, an IE is not viable due to the low number of treatment units (5 new villages for tenure, and 44 village already under different stages of village delimitation before RESTORE start-up). The small sample size means that there is likely not sufficient power to detect changes in outcomes in a causal framework. The RESTORE currently plans to support 11 village savings and loans associations (**VSLAs) in Ghana and 22 VSLAs in CDI.** In Ghana, 122 individuals (including 29 male, 56 female and 37 youth) have been given alternative livelihood support, while the number of enterprises they compose is unclear. Depending on if sufficient individual beneficiaries can be identified prior to data collection, this component may be amendable to a quasi-experimental IE, matching individuals who have received the treatment to individuals in comparison villages that have not. Overall, the activities not suitable for an IE are amenable to assessment through a rigorous PE, through data collection by the evaluation team as well as building upon monitoring data already being collected by the IPs as per the RESTORE Monitoring, Evaluation and Learning plan.

Based on information the ET obtained in the September ecological scoping trip, the ET determines that the **off-farm restoration** component in Ghana, and associated field-based conservation and biodiversity indicators, is amenable to evaluation through a quasi-experimental Difference-in-Difference (DID) approach. However, we do not expect landscape level impacts on biodiversity from the off-farm boundary planting currently planned in CDI, and thus do not recommend field ecological data collection though satellite imagery will be used to capture changes in tree cover. We also recommend a Pause and Reflect to update and refine RESTORE's theory of change (TOC) for each of the SAs.

USAID has identified several priority learning questions about the effectiveness and benefits from SA2**,** which focuses on **improved landscape governance** through LMBs. However, given the small number of new LMBs, which are the main unit of treatment for SA2, the FA discusses the potential for a PE centered on a before-after case study. A PE approach could be used to explore variation in outcomes between RESTORE-supported LMBs and LMBs that are not supported by RESTORE.

Given the dearth of counterfactual-based studies on RESTORE's SAs, even knowledge generated through a well-designed PE for some components would advance USAID's and the HEARTH portfolio's learning agenda. Furthermore, a PE would add value by strengthening the program's TOC. Baseline data from the evaluation will provide a key source of monitoring and evaluation (M&E) data and provide important contextual information that can be used to promote more effective, adaptive programming.

The main outcomes of interest for RESTORE center on livelihood and human well-being (socio-economic status, food security, health, etc.) and reducing threats to forests, thus improving biodiversity and conservation. An evaluation of RESTORE would be tasked with exploring whether the program:

- Decreased stress on/reduced threats to biodiversity and improved biophysical conditions?
- Changed behaviors and norms around conservation?
- Lead to changes in land and resource management and governance, including collective action?
- Affected livelihoods, well-being, and rural poverty?
- Lead to differential effects or negative externalities, including for women, youth, and/or areas with government-supported interventions and long-standing trade relationships?
- Achieved sustainable outputs/outcomes/impacts?

More specifically, a mixed-methods evaluation of RESTORE that combines performance and impact methods presents several learning opportunities:

LEARNING QUESTIONS FOR SA1

- How are different types of farmers and landowners incentivized to promote good conservation practices? Types of farmers to consider are farmers of high and low affluence, farmer land tenure types (sharecropping, abuna, abusa, rent), farmer immigrant status, and age of farms.
- Have land and/or tree tenure arrangements effectively encouraged conservation practices? If yes, which incentive package(s) have been effective in promoting conservation practices? And to which subpopulation? Incentive package components to consider include secured tenure arrangements, sensitization about socioeconomic and environmental benefits of shade trees, perception of farmers regarding climate vulnerability, high demand for cocoa volumes and strong

presence of traders, biologically and socially preferred tree species, and economic incentives such as premiums and access to materials.
- If the enabling policies and access to materials are put into place, which trees will farmers plant and with what purpose (shade, timber, additional tree crop)?
- Does improved community understanding of ecosystem benefits lead to deliberate efforts towards reducing threats to biodiversity?
- Do on- and off-farm restoration efforts lead to sustained impact on increased flora and fauna biodiversity of critical ecosystems and species in the RESTORE treatment areas? On water quality and quantity in the RESTORE treatment areas? And on zoonotic disease risks to neighboring communities?

LEARNING QUESTIONS FOR SA2

- Does the participatory landscape governance process give women and youth voice and influence in decision-making, especially in Farmer Groups and village organizations?
- Have capacity-building interventions been effective at strengthening LMBs, Farmer Groups, and village organizations? If yes, which ones? Why or why not?
- Have landscape stakeholders contributed towards strengthening LMBs, Farmer Groups, and village organizations to be effective in delivering their mandate? How do results vary by engagement methods?
- Have bottom-up governance approaches designed by the LMBs been effective in promoting sustainable landscape management? If yes, which governance approaches have been the most successful? Is this approach scalable?
- Has collaboration between the private sector and the communities yielded positive synergies in improving the livelihoods of community members?

LEARNING QUESTIONS FOR SA3

- What are the priority factors determining the adoption of regenerative, sustainable cocoa farming? What are the most and least easily adopted practices of regenerative agriculture by farmers, and why? Are there government policies that conflict with regenerative agriculture?
- Does regenerative sustainable cocoa production contribute to a reduction in threats to biodiversity, and if so, through which mechanisms?
- Does regenerative sustainable cocoa production enhance ecosystem services important for agriculture (e.g., pollination, soil fertility, water quality and quantity)? What impact does this have on household food security and health, if any?

LEARNING QUESTIONS FOR SA4

- Has RESTORE motivated women and youth entrepreneurs to start up enterprises? If yes, what has been the most important market and/or contextual factor in motiving women and youth entrepreneurs to initiate enterprises?
- Have women's and youths' livelihoods improved as a result of diversification approaches?
- Have long-term investment portfolios been initiated as a result of landscape partnerships?

- Which investment potentials provide the most sustained income stream to the landscape?
- Do diversified income sources for forest fringe communities reduce threats to biodiversity through reduced pressure on natural habitats and forests?

RELATIONSHIP TO THE HEARTH LEARNING AGENDA

The RESTORE learning questions contribute to Learning Questions 2 through 5 of the overall USAID HEARTH Learning Agenda.

The RESTORE focus on cocoa agroforestry adoption, linked with landscape level conservation effort, echoes the HEARTH central idea that conservation and cross-sectoral well-being of the community is a mutually enforcing process (Learning Question (LQ)5). As a whole, the RESTORE learning questions for SA 1 and 3 test the approach of promoting cacao agroforestry and Climate Smart Agriculture (CSA) practices for congruent improvement in economic and ecological outcomes at the household and community level. Over time, RESTORE can provide an understanding of how economic incentives provided through CSA influence farming communities' conservation attitudes and efforts, and how it then in turns reenforces the upholding of CSA principles.

RESTORE learning questions related to effectiveness of on- and off-farm conservation practice adoption directly contributes to HEARTH Learning Agenda LQ3 of what incentives changes conservation attitudes and behavior in agricultural landscapes. The RESTORE interventions address incentives to adopt conservation behavior on-farm (shade-tree and CSA practices) and off-farm (tree-planting and restoration management) through providing incentives at the household level (information and capacity, income from improved cocoa yields, income from alternative livelihoods, and tenure-related incentives) and at the community level (community-level tree planting support and LMBs). The adoption of these conservation practices offers opportunity to then test the assumption that adopting these practices can improve cross-sectoral community wellbeing (Learning Agenda LQ2), including economic well-being, food security, and health well-being.

Aside from these questions focused on household and community-level decision-making and outcomes, the landscape-level focus of RESTORE, and the connection between on-farm and off-farm restoration efforts, particularly offers a unique opportunity to investigate the landscape-level processes between ecological well-being and human's cross-sectoral well-being pertaining to Learning Agenda LQ4 and LQ5. These processes include whether changes in conservation attitude and/or economic well-being on cocoa-intensive farm areas spills over to threat reduction in areas closer to Protected Areas, and whether improvement in ecological health at the landscape level leads to reduction in zoonotic disease spillover into human populations.

RECOMMENDATIONS

The FA team recommends the following:

- **Evaluation Priorities:** A rigorous counterfactual-based PE or IE that measures biodiversity, conservation, and zoonosis outcomes will require a large amount of primary biophysical data collection. At present, the IPs do not plan to measure and collect many of the necessary field-based biophysical measures as part of the project M&E. As a result, all of these measures would need to be fully covered by the evaluation.

Assuming the research budget will be limited, the FA team recommends prioritizing the budget for, first and foremost, a PE or IE of the off-farm restoration component in Ghana. This is because of (1) USAID's conservation and biodiversity learning priorities, (2) the potential that the off-farm component will offer a more rigorous causal inference opportunity than the on-farm activities, and (3) the dearth of rigorous evidence on forest restoration interventions.

Second, we recommend funding for a PE of the alternative livelihood component. This is because (1) the alternative livelihood component offers the most rigorous PE option as noted above, and (2) there is no rigorous research and evaluation into their effectiveness and efficacy, despite their widespread use in development programming.

On-farm plot-level biophysical indicators to assess on-farm biodiversity would be technically feasible to collect, but their value to learning about program impact would be limited. As we note above, it is likely not possible to find a valid comparison group for the on-farm cocoa agroforestry activities. This means that on-farm biodiversity outcomes could measure trends over time or be used to assess relationships with other outcomes, but not as impact estimates. An alternative to direct biophysical measurement might be to include basic observational measures into a farmer survey.

Table 1. *Overview of Potential Evaluation Approaches Mapped to Each Program Strategic Approach*

Strategic Approach	Intervention sites	Potential Evaluation Method(s)
SA1: Tenure and tree planting	On-farm	PE; Case study
	Off-farm	Difference-in-Difference (IE)
SA2: Land Management Boards	LMBs, On-farm	PE
	LMBs, Off-farm	PE
SA3: Regenerative agriculture / cocoa agroforestry	On-farm	PE
SA4: Alternative livelihood	On-farm	Performance/ Matching or Difference-in-Difference (IE)

- **Design Trip:** We recommend a scoping/design trip in May 2023 to collect the necessary information to finalize the RESTORE evaluation design for the on-farm and off-farm components. The evaluation design trip would facilitate identification of the best possible comparison communities for any of the activities that might be subject to a PE, including on-farm cocoa agroforestry, land and/or tree tenure, and alternative livelihoods. Additional information is required about the communities that will receive land tenure strengthening as well as the geographies and details on cocoa-agroforestry programming for other farmer groups/cooperatives and traditional cocoa farmers. This would provide an understanding of the range of agroforestry programs and assistance provided in the area among non-RA/ofi cooperatives.

The scoping trip would also support the research team's ability to maximize any learning opportunities by overlapping the IE off-farm areas with on-farm PE areas. If we maximize overlap between the IE and PE areas, we could cost-effectively target data collection for human well-being to maximize available funds for bio-physical data collection.

- **Pause and Reflect:** The FA team also recommends an update to the whole of project TOC, along with individual SA TOCs following the May 2023 scoping trip to reflect the final implementation plans, especially with regards to the off-farm restoration activity plan, reducing emissions from deforestation and forest degradation in developing countries, and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries (REDD+) support, and payment for ecosystem services (PES) certification schemes in CDI.

I. Introduction and Background

The following section introduces the assessment, including the primary objectives, purpose, audience and intended users, and information sources, as well as some background and context for the RESTORE Activity.

INTRODUCTION

The objective of this FA is to assess the possible options for a rigorous evaluation of the USAID/West Africa RESTORE Activity in Ghana and CDI. This is a five-year program beginning in 2022. This assessment, conducted under the Integrated Natural Resources Management (INRM) Task Order, includes identifying illustrative IE and/or PE design options that meet Agency-wide HEARTH and Mission learning interests and are considered feasible for a credible assessment of impacts, should USAID decide to conduct an evaluation of the activity. This report provides an assessment of the RESTORE Activity's current TOC, evaluation design options and potential methods, challenges, and limitations to conducting an IE, potential outcomes and data sources, illustrative costs, and next steps.

PURPOSE, AUDIENCE, AND INTENDED USES

USAID commissioned this desk-based FA of evaluation design options that could be used to rigorously evaluate the impacts of the RESTORE Activity. The FA will lay the groundwork for finalizing the research methods for a rigorous IE or PE, if USAID decides it would like to conduct such an activity. To draft the FA, the research team reviewed the project's background documents, workplan, and TOC, as well as evidence on intervention effectiveness. The FA team assessed the existing and planned M&E data sources while identifying additional data needs, and the FA report includes budget estimates for the various design options.

The primary audience for the FA is USAID/West Africa, USAID/Washington D.C., USAID/Bureau for Africa/Office of Sustainable Development, and USAID/Environment, Energy, and Infrastructure/Natural Environment. Secondary audiences include RA and ofi as the primary IPs for the activity and other local partners. USAID will use the results of this FA to gain an understanding of available design options and methods that could be used for an IE or PE of the RESTORE Activity, the types of outcomes that could be measured under such designs, the additional information that would be required to proceed with a rigorous evaluation design, and an illustrative indication of costs.

BACKGROUND AND CONTEXT

Commodity production has played a significant role in global deforestation, and associated greenhouse gas emissions and biodiversity loss (WRI 2018). Cocoa was the fourth largest driver, behind beef, palm oil, and soy (Weisse and Goldman 2021).

Cocoa grows in biodiverse lowland and tropical forest regions. In Ghana and CDI this includes landscapes within the Guinean forest biome, which is a biodiversity hotspot, home to more than 60 endemic mammalian species. Many of these species are endangered or threatened, such as the Diana monkey, the pygmy hippopotamus, and Jentink's duiker.

A number of factors drive deforestation in cocoa producing landscapes, including agricultural expansion, weak and mismatched land and resource governance, excessive local harvesting of wood for fuel, and insufficient sustainability practices (e.g., climate-resilient agroforestry), as well as a lack of clear economic valuation of standing forests, trees, and restored native forests. Among other issues, agricultural expansion is driven by global demand for cocoa, and declining yields and farmer incomes. Climate change has driven increased extreme weather variability, which has led to drought, disease, and reduced pollination. These factors have combined to further reduce cocoa yields. As cocoa yields continue to decline, land conversion is exacerbated in a vicious feedback cycle.

Cocoa farmers in West Africa earn low incomes and a vast majority are below the poverty line. As there are few non-cocoa income opportunities and the costs of switching to non-cocoa production are high, farmers choose to compensate for declining yields by producing more cocoa on more land. In CDI, this is compounded by weak enforcement of protected areas that facilitates forest conversion (Myers 2021).

To avoid forest conversion and restore native forests, RESTORE's interventions must address farmers' low incomes and yields. 'The Alliance,' which consists of RA and ofi in partnership with multinational chocolate companies, farmer cooperatives, and local partners – will over five years establish the technical capacity, policy implementation approaches, and economic incentives to bring cocoa producing families, governments, and private sector actors together in a joint endeavor to secure improved livelihoods from cocoa farming, promote socially inclusive additional economic opportunities, increase tree cover, and contribute to national and corporate emission reduction targets.

For the RESTORE Activity, the Alliance and its partners selected three priority areas to conserve biodiversity in protected areas and their buffer zones in critically threatened, highly biodiverse and culturally diverse, impoverished landscapes in the Guinean forest landscape of Ghana and CDI (see **Figure 1** below). In these three landscapes, the RESTORE Activity is expected to have a direct impact on an estimated 15,000 farmers (ɵ) managing 50,000 ha of farmland and working in the supply chain of ofi, in partnership with chocolate brands in the project landscapes. This includes 50 percent of active participation of women and youth in LMB activities.

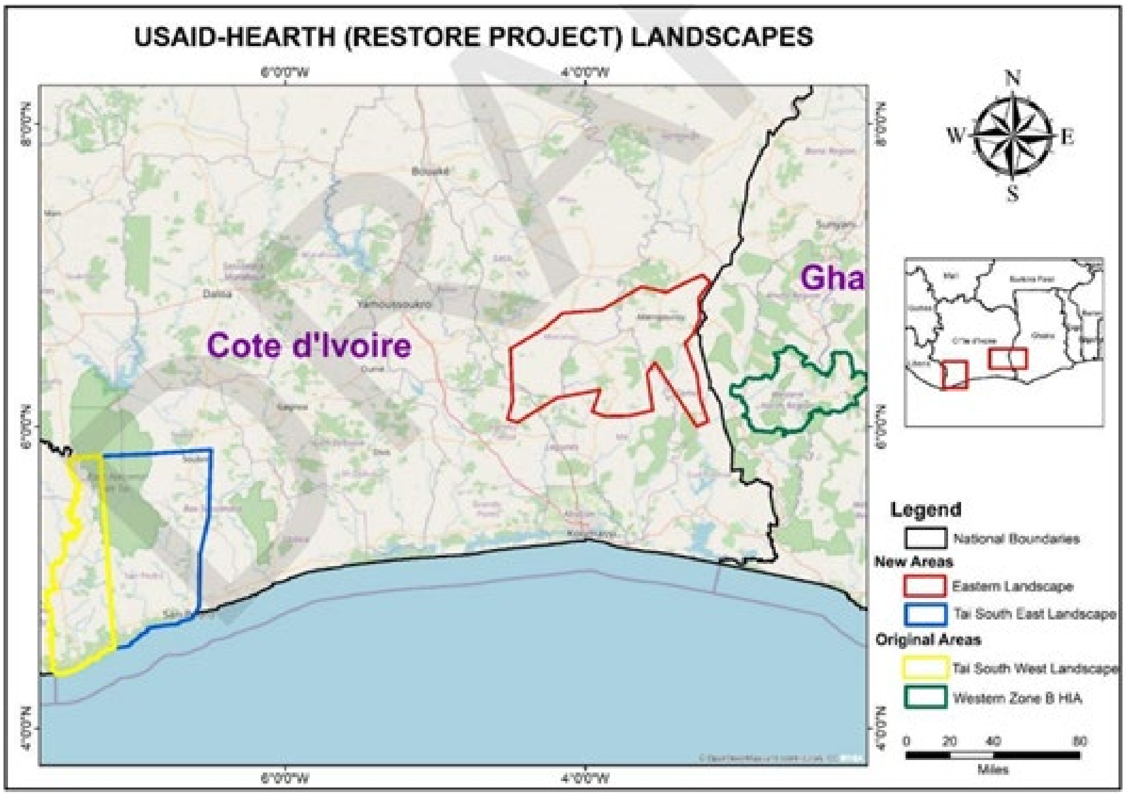

Figure 1. *Map of RESTORE Landscapes*

Based on the draft work plan and program description, RESTORE's Strategic Approaches are as follows:

- **SA1:** Improve tree and/or land tenure processes and strengthen incentives for tree growing and conservation to restore tree cover and protect forest.
- **SA2:** Establish and strengthen the business and governance capacity of LMBs and improve the conservation and natural resource management support that they provide to farmers.
- **SA3:** Increase the use of climate-smart, more productive, regenerative and sustainable cocoa production by improving farmers' capacities, knowledge, and resources.
- **SA4:** Promote and strengthen forest-friendly livelihood diversification through women- and youth-inclusive approaches that improve skills and access to funding, inputs, and markets.

Through these SAs, RESTORE's ultimate objectives are to improve livelihoods and well-being, reduce deforestation, increase forest restoration at scale, and promote resilient high yield agroforestry systems.

INFORMATION SOURCES

The FA team consulted a variety of documents and other information sources to inform this assessment, including:

- Discussions with RA and ofi;
- Discussions with USAID;
- Detailed logic model, TOC, and results chains specific to the RESTORE Activity;

- Draft Year 1 RESTORE Workplan which outlines the nature of ongoing and planned activities for the RESTORE Activity, and general anticipated timing of key activities;
- Draft Measurement, Evaluation, Research and Learning (MERL) plan for the RESTORE Activity;
- In-person participation in the Activity Start-Up Workshop (facilitated by Measuring Impact II in June 2022);
- Maps and geospatial datasets provided by the IPs about the location of project landscapes and farmer cooperatives;
- Working research papers from the IPs on cocoa agroforestry;
- Discussions with academics and other IPs that are engaged in other similar research and/or programming in Ghana and CDI;
- Literature search and review of academic and grey literature on IE associated with cocoa agroforestry, agroforestry and tenure interventions, alternative livelihood interventions and forest restoration programming; and
- Technical and research reports commissioned by USAID on evaluating zoonotic spillover risk.

II. Strategic Approaches

The following section provides further details on the interventions planned under each of the RESTORE Activity's SAs, including the IPs and timing of activities. This is followed by a discussion of the whole project's TOC and specific testable results chains for each SA. We elaborate on key underlying assumptions and potential weaknesses of each SA. Lastly, the FA team formed key learning questions associated with each SA following consultation of the FA SOW, program documents and consultation with IPs.

INTERVENTION DETAILS

The section below is based on information provided in the first draft Year 1 Workplan, activities description in the cooperative agreement, calls with RA and ofi, and the map of the settlement areas where each IP will be conducting their activities provided by the IPs.[2]

The interventions will take place in four different Guinean forest landscape, with one in Ghana and three in CDI. The program will involve 21 cooperatives and three farmer groups, which covers about 15,000 supply-chain farmers of the Alliance and 50,000 hectares of farmland.

- South Taï National Park Landscape (Côte d'Ivoire)
- Beki-Bossematie Eastern CDI Landscape (Côte d'Ivoire)
- Sui River Landscape (Western Zone B Health Impact Assessment (HIA)) (Ghana)

According to the RESTORE workplan, the primary interventions in Q1 FY 2023 are activities associated with SA1 (Improve tree and/or land tenure processes and strengthen incentives for on- and off-farm tree growing and conservation), SA2 (Establish and strengthen LMBs), and SA3 (Increase farmers' use of climate-smart regenerative cocoa production). SA4 (Livelihood diversification) will be the last to be implemented as it involves engagement with communities to identify which livelihoods will be most appropriate to promote, as well as identifying target recipients.

A simplified version of the Year 1 Workplan is provided in Appendix B, and a summary for each SA is provided below, along with the main activities and timeline.

STRATEGIC APPROACH 1

Improve tree and/or land tenure processes and strengthen incentives for tree growing and conservation to restore tree cover and protect forest.

[2] This section was also updated after the September 2023 ecological scoping trip to reflect information learned.

SA1 includes four main components: 1) support for on-farm tree planting, 2) support for tenure (land tenure in CDI, and tree tenure in Ghana), 3) support for REDD+ benefits in CDI,[3] and 4) off-farm restoration through Landscape Action Plans.

SA1 activities begun in Q1 FY 2023 with awareness building, stakeholder mobilization, and boundary mapping. Based on conversations with RESTORE IPs, we learned that activities for on-farm tree planting and support for tenure will commence first in Q1 FY 2023. On-farm planting is expected to occur from May to July 2023 and on-farm activities will be administered through the farmer cooperatives.

To plan for off-farm tree planting between June and August 2023, the IPs will start building awareness, mobilizing key stakeholders, and identifying areas for conservation in October 2022, and establish tree nurseries from November 2022 to January 2023. In CDI, RESTORE will focus on establishing and strengthening the governance capacity of LMBs in Year 1, and explore identifying restoration areas for off-farm tree planting either in Year 1 or Year 2, after LMBs are maturely established.

For the tenure interventions, in CDI, RESTORE, working with Agence Foncière Rurale (AFOR) will assist farmers in obtaining land tenure in the five villages where AFOR is not already present. In addition, RESTORE will plant native trees on the boundaries of 49 RESTORE villages that has been delimited by AFOR (including the 5 villages AFOR is newly intervening in).

In Ghana, RESTORE will facilitate digitized tree registration with the Resource Management Support Centre (RMSC) of the Forestry Commission (FC); RESTORE is continuing with the Memorandum of Understanding signing process with RMSC and FC, and expects to develop the registration platform and train community enumerators in later years.

STRATEGIC APPROACH 2

Establish and strengthen the business and governance capacity of LMBs and improve the conservation and natural resource management support that they provide to farmers.

SA2 involves the establishment of LMBs and Land Management Plans, along with supporting LMBs to improve management structures, incorporate adaptive management and community participation, as well as strengthen the administrative and management capacity of older LMBs. In CDI, in Q4 2022 and Q1 2023, RESTORE will begin awareness building, landscape scoping studies, defining LMB structures and management plans. The project aims to revive and expand an existing LMB in Tai landscape, and create new LMB in the eastern landscape in CDI in Q2 FY 2023 to start implementing the management plans. The three existing LMBs in Ghana's Sui River landscape are more mature. In this area, RESTORE plans to guide the LMBs to define indicators and a monitoring plan starting in Q1 FY 2023.

[3] In Côte d'Ivoire, RA is exploring brokering villages' participation in REDD+ benefits. Activities will commence in Q4 FY2022 and Q1 FY2023 with community boundaries delineation, village mapping, and restoration site identification, and brokering a relationship with the REDD+ secretariat.

STRATEGIC APPROACH 3

Use of climate-smart, more productive, regenerative, and sustainable cocoa production by improving farmers' capacities, knowledge, and resources.

SA3 activities include developing and providing trainings to farmers on regenerative agriculture and sustainable cocoa production. Through youth service groups and media, RESTORE will provide technical support and disseminate knowledge on regenerative agricultural technique, including the use of shade trees and other tree crops, as well as forest conservation, regenerative soil management practices, use of organic matter as compost, intercropping with leguminous plants and fruit/nut trees, and establishing emergency plans to deal with extreme weather events. RESTORE will also evaluate existing financial mechanisms for farmers to invest in regenerative agriculture practices. In Ghana, SA3 activities will start in October 2022 with post-harvest practices training. In CDI, support and training for CSA practices is expected to begin in January 2023. The activities involve creating an enhanced training curriculum, a training-of-trainers who will support cooperative farmers throughout the cropping season through July 2023. RESTORE will also monitor data on cocoa yield, price, and premiums to better understand the profitability of regenerative agriculture practices.

STRATEGIC APPROACH 4

Promote and strengthen forest-friendly livelihood diversification through women- and youth-inclusive approaches that improve skills and access to funding, inputs, and markets.

SA4 will be the last component to be implemented as it involves engagement with communities to identify target women and youth-focused small and medium enterprises (SMEs) as recipients. Recipients for the VSLA scheme will be selected by March 2023, and the recipients will be connected to financing from March to October 2023. For women and youth, RESTORE will provide training on enterprise planning from November 2022 to February 2023. RESTORE will also integrate livelihood scheme planning into the LMB training process.

THEORY OF CHANGE

Initial results chains for each SA and the whole of project were developed during the co-design phase. These results chains were subsequently updated during the RESTORE start-up workshop. The FA team produced simplified versions of these TOC for each SA and flagged logic problems and significant assumptions. The results chains for each SA are provided below (see **Figure 2** through Figure 6), and an overall TOC, as listed in RESTORE Year 1 workplan, is provided in Appendix E.

The FA team recommends an update to the whole of project TOC, along with individual SA TOCs in April/May 2023 to reflect the final implementation plans, especially with regards to the off-farm restoration activity plan, REDD+ support, and PES certification schemes in CDI.

The TOC should also be updated to reflect the actual level of overlap between settlements involved in both the on-farm and off-farm programming. Further, the TOCs for both SA1 and SA3 include mechanisms that rely on knowledge and awareness raising (around the benefits of planting trees, how to keep them alive, benefits of regenerative agriculture practices, etc.) as critical pathways for behavior change. However, these mechanisms alone may only provide weak incentives for behavior change. It may be important that activities are implemented that more directly reduce costs or increase benefits of adopting and maintaining practices related to reforestation and long-term management of planted trees.

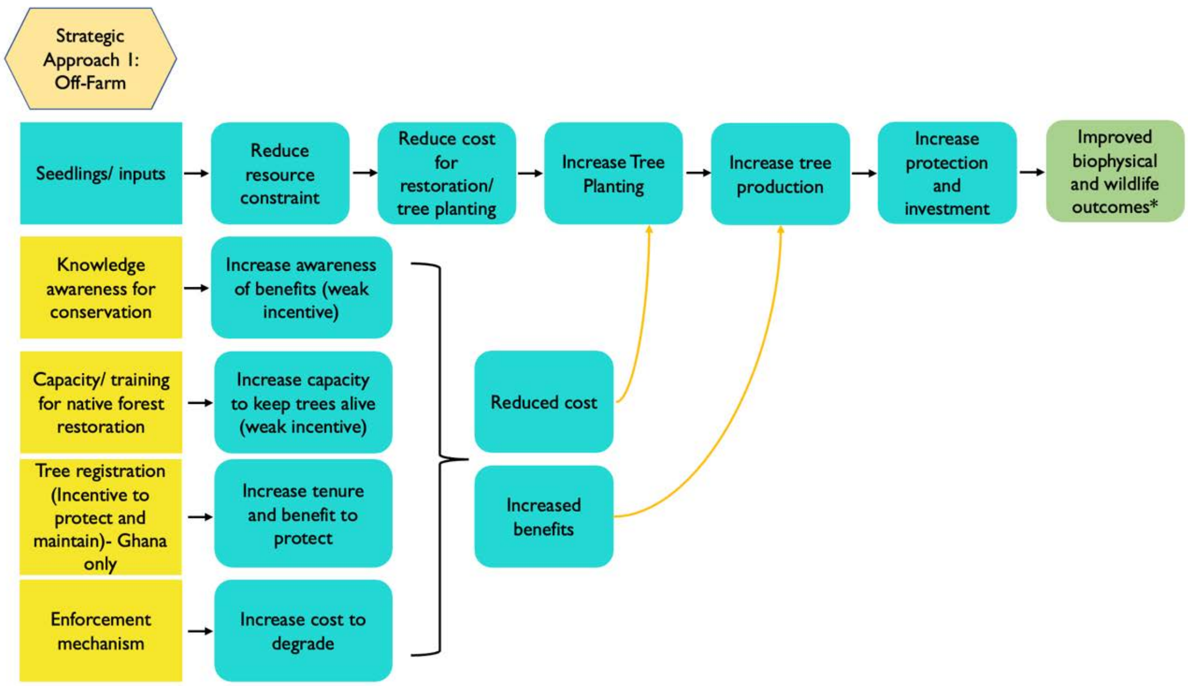

Figure 2. *Results Chain for SA1: Improve Tree and/or Land Tenure Processes and Strengthen Incentives for Tree Growing and Conservation to Restore Tree Cover and Protect Forest (Off-farm)*

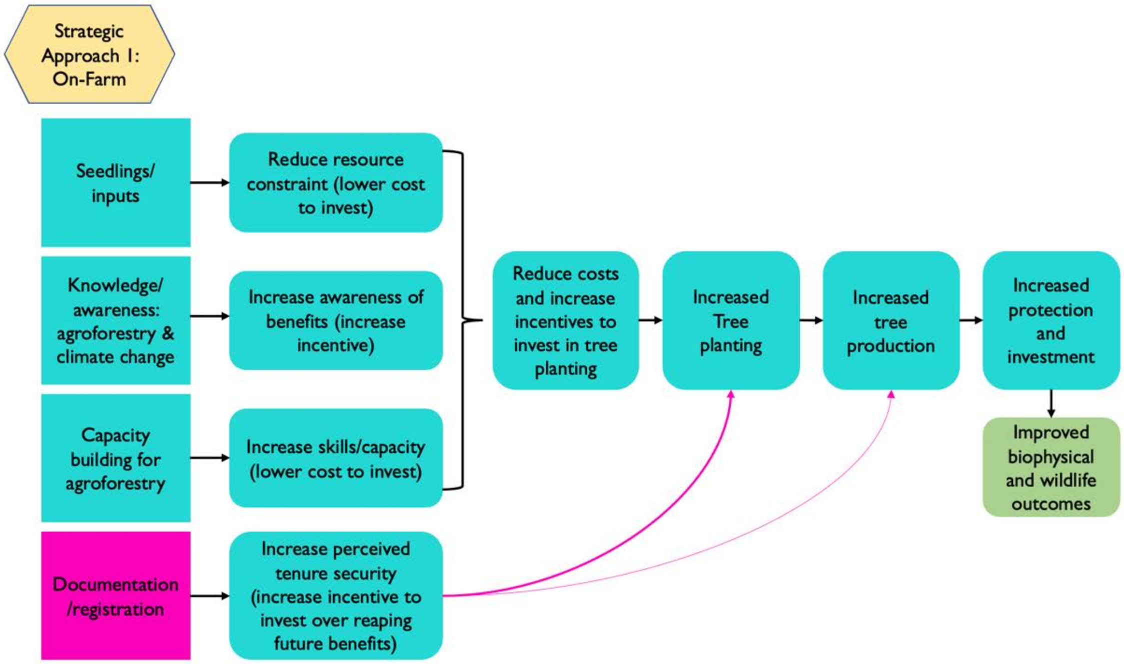

***Figure 3**. Results Chain for SA1: Improve Tree and/or Land Tenure Processes and Strengthen Incentives for Tree Growing and Conservation to Restore Tree Cover and Protect Forest (On-farm)*

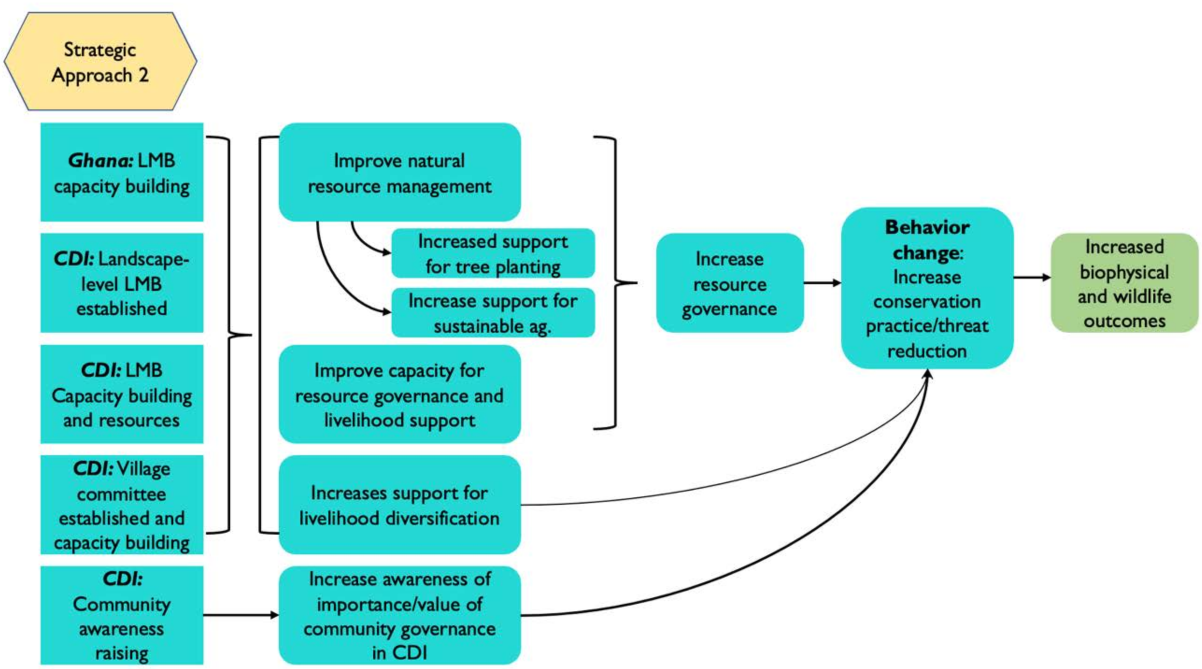

***Figure 4.** Results Chain for SA2: Establish and Strengthen the Business and Governance Capacity of LMBs and Improve the Conservation and Natural Resource Management Support that they Provide to Farmers*

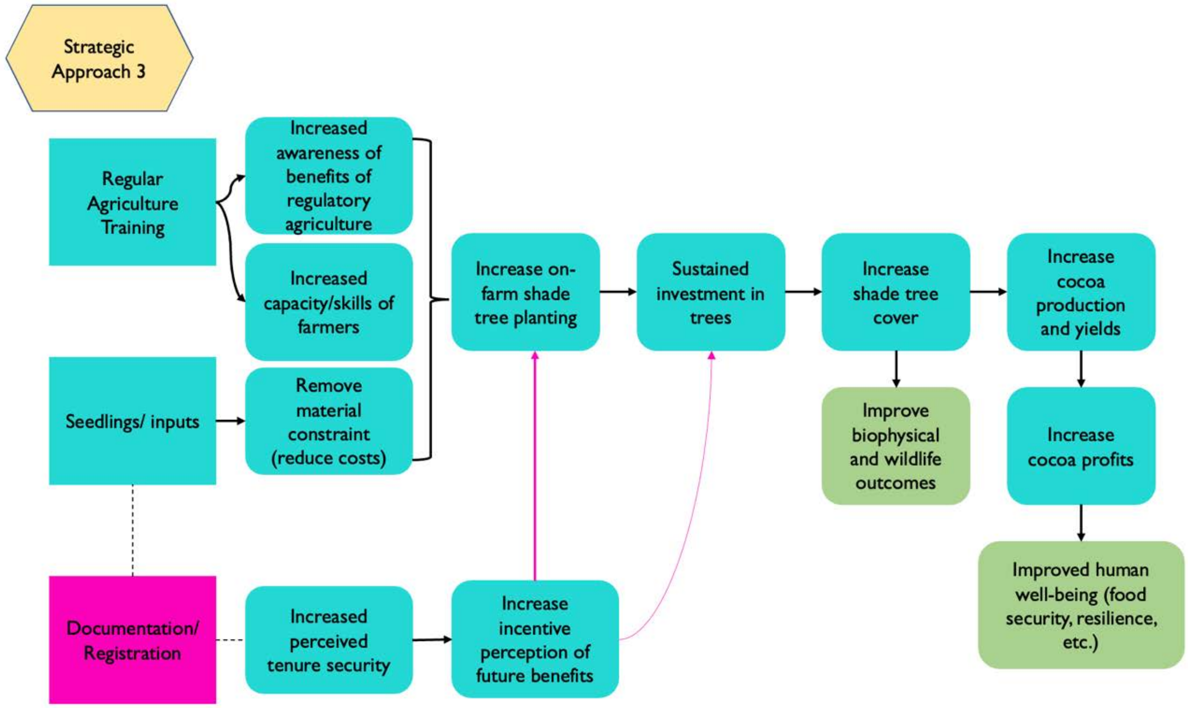

Figure 5. *Results Chain for SA3: Use of Climate-smart, More Productive, Regenerative and Sustainable Cocoa Production by Improving Farmers' Capacities, Knowledge, and Resources*

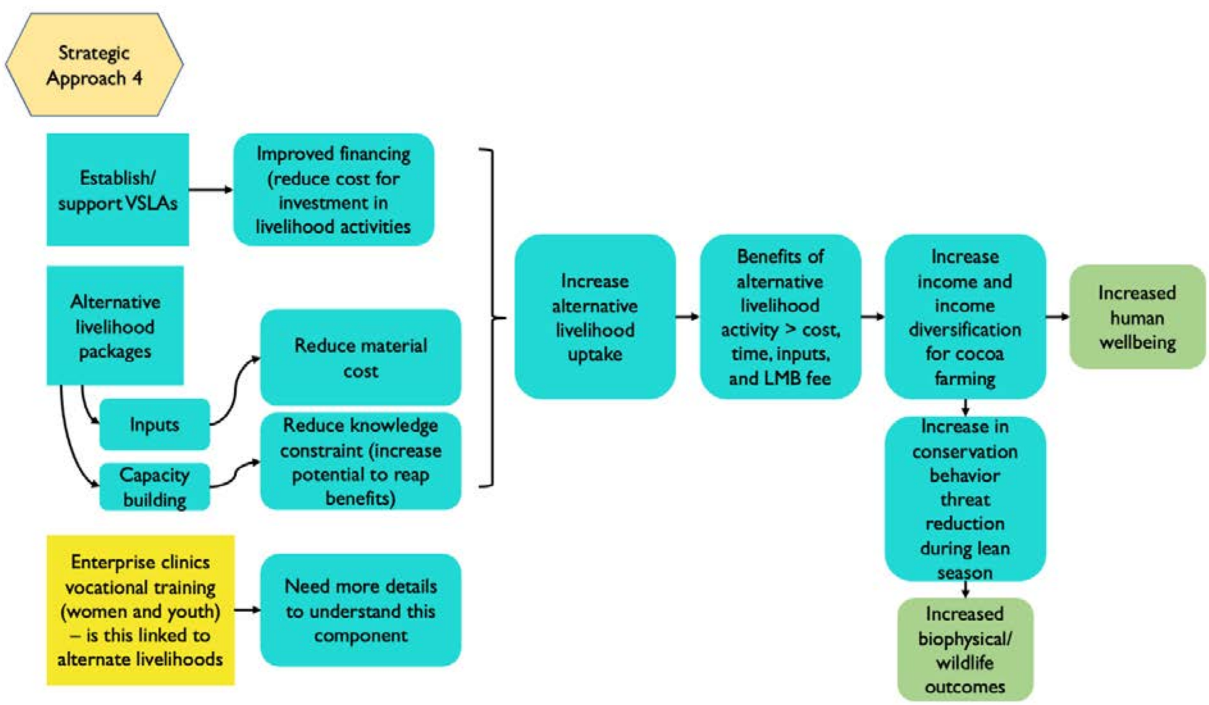

Figure 6. *Results Chain for SA4: Promote and Strengthen Forest-friendly Livelihood Diversification through Women- and Youth-Inclusive Approaches that Improve Skills and Access to Funding, Inputs, and Markets*

ZOONOSES TOC

In addition to the RESTORE SA TOCs formed at program design, USAID has asked the FA team to consider the implication of RESTORE for zoonotic outcomes and identify opportunities to contribute to the knowledge gap between reforestation efforts and zoonotic disease transmission, given the increased attention to the connection between ecological change and zoonotic disease transmission risk. Forest disturbance and land conversion impact the risk factors driving spillover of viruses by increasing exposure of humans and livestock to wild animals. Conversion of natural habitat to agriculture or other land uses leads to: (1) biodiversity loss (Newbold et al. 2015); (2) changes in the distribution and abundance of zoonotic host species (Gibb et al. 2020); (3) increased exposure and increased frequency and intimacy of contact between wildlife (Bloomfield 2020), humans, and domesticated species (Pulliam et al. 2012). Exposure changes through changes in forest use, forest access, influx of agriculture (particularly bridge hosts), wildmeat demand, and wildlife supply. All three of these factors can increase the likelihood of emergence. We include a more detailed discussion regarding the link between conservation programs in general and zoonosis outcomes in Appendix G.

We identified four pathways of how landscape change may increase the risk of zoonotic spillover:

- Habitat conversion changes wildlife range, which changes the density and distribution of reservoir hosts. This subsequently changes hosts' carrying capacity for pathogens.
- Agricultural intensification can lead to habitat conversion and change resource availability for different animals; in some cases, this might improve conditions for some animals and decrease available food/shelter resources for others.
- Habitat conversion can be stressful for wildlife; stress reduces immune response and leads to increased pathogen prevalence and loads. This results in increased levels of pathogen release and excretion.
- Reduced/shared resources can increase interspecies contact, promoting pathogen exposure, spread and survival. On the other hand, the creation of bio corridors or connectivity patches might affect the human-host interaction due to increased presence of wildlife.

KEY ASSUMPTIONS

The FA team notes several strong assumptions underlying the RESTORE SA TOCs with regard to the strength of the incentives provided by program activities in motivating sustained tree planting, management and conservation, and decreased land clearing at the farm and community level.

- There is an assumption that awareness of conservation importance combined with governance support for LMB resource management will lead to sustained management of conservation areas.
- RESTORE assumes that the primary barriers to off-farm tree planting and preservation are lack of inputs and conservation awareness, and a lack of market opportunities for other non-cocoa activities, hindering degradation. There is weak existing evidence that training and start-up costs alone lead to sustained adoption for regenerative agriculture practices; increased awareness and training on restoration and community governance does not address the financial, coordination,

and political barriers to promote a commitment to restoration. As a result, RESTORE's stated objective is to design market opportunities for communities near off-farm sites that are integrated (versus restrictive) with nature.

- This suggests that the primary barriers to off-farm tree planting are the lack of knowledge and lack of start-up resources (i.e., seedlings).
- There is an assumption that native/shade trees will lead to sufficiently large short- or long-term yields and profits will outweigh the cost of adoption (planting and change in management practice).
- There is an assumption that improved on-farm productivity will not motivate further land clearing.
- There is an assumption that alternative livelihood options for women and youth will lead to enough sustained income generated, and perceived future security of said income to the household, and reduce the pressure to expand cocoa farmland and reduce dependency on cocoa income.

LEARNING QUESTIONS

The FA team formed key LQs associated with each SA from consultation of the FA SOW, TOC, program documents and consultation with IPs.

LEARNING QUESTIONS FOR SA1

- How are different types of farmers and landowners incentivized to promote good conservation practices? Types of farmers to consider are farmers of high and low affluence, farmer land tenure types (sharecropping, abuna, abusa, rent), farmer immigrant status, and age of farms.
- Have land and/or tree tenure arrangements effectively encouraged conservation practices? If yes, which incentive package(s) have been effective in promoting conservation practices? And to which subpopulation? Incentive package components to consider include secured tenure arrangements, sensitization about socioeconomic and environmental benefits of shade trees, perception of farmers regarding climate vulnerability, high demand for cocoa volumes and strong presence of traders, biologically and socially preferred tree species, and economic incentives such as premiums and access to materials.
- If the enabling policies and access to materials are put into place, which trees will farmers plant and with what purpose (shade, timber, additional tree crop)?
- Does improved community understanding of ecosystem benefits lead to deliberate efforts towards reducing threats to biodiversity?
- Do on- and off-farm restoration efforts lead to sustained impact on increased flora and fauna biodiversity of critical ecosystems and species in the RESTORE treatment areas? On water quality and quantity in the RESTORE treatment areas? And on zoonotic disease risks to neighboring communities?

LEARNING QUESTIONS FOR SA2

- Does the participatory landscape governance process give women and youth voice and influence in decision-making, especially in Farmer Groups and village organizations?
- Have capacity-building interventions been effective at strengthening LMBs, Farmer Groups, and village organizations? If yes, which ones? Why or why not?
- Have landscape stakeholders contributed towards strengthening LMBs, Farmer Groups, and village organizations to be effective in delivering their mandate? How do results vary by engagement methods?
- Have bottom-up governance approaches designed by the LMBs been effective in promoting sustainable landscape management? If yes, which governance approaches have been the most successful? Is this approach scalable?
- Has collaboration between the private sector and the communities yielded positive synergies in improving the livelihoods of community members?

LEARNING QUESTIONS FOR SA3

- What are the priority factors determining the adoption of regenerative, sustainable cocoa farming? What are the most and least easily adopted practices of regenerative agriculture by farmers, and why? Are there government policies that conflict with regenerative agriculture?
- Does regenerative sustainable cocoa production contribute to a reduction in threats to biodiversity, and if so, through which mechanisms?
- Does regenerative sustainable cocoa production enhance ecosystem services important for agriculture (e.g., pollination, soil fertility, water quality and quantity)? What impact does this have on household food security and health, if any?

LEARNING QUESTIONS FOR SA4

- Has RESTORE motivated women and youth entrepreneurs to start up enterprises? If yes, what has been the most important market and/or contextual factor in motiving women and youth entrepreneurs to initiate enterprises?
- Have women's and youths' livelihoods improved as a result of diversification approaches?
- Have long-term investment portfolios been initiated as a result of landscape partnerships?
- Which investments potentials provide the most sustained income stream to the landscape? Do diversified income sources for forest fringe communities reduce threats to biodiversity through reduced pressure on natural habitats and forests?

III. Overview of Evaluation Approaches

To preface a discussion on state of the evidence of restoration program impacts, this section provides a brief summary of evaluation approaches commonly used to evaluate conservation programs. See Appendix F for a more detailed discussion of each evaluation method considered.

IMPACT EVALUATIONS

IEs measure the causal impact of a program, or the difference in outcomes caused by a program or intervention and not by other external factors. IEs rely on a counterfactual or comparison/control group to rigorously distinguish causality from association. IEs employ experimental and quasi-experimental methods to identify treatment effects. Experimental approaches measure the causal impact of programs through randomized assignment (e.g., randomized control trials (RCTs)); Whereas quasi-experimental approaches, such as DID and statistical matching, measure causal impacts without randomization.[4] In quasi-experimental approaches, the comparison group is purposefully selected, constructed or matched to create the best and most credible comparison for treatment areas. The designation of an evaluation as an IE versus PE ultimately depends on the validity of the control group or counterfactual.

The treatment of interest for an IE can be designed at the community, household, or individual level. But different units of analysis are possible, such as focal species (e.g., rodents, bats, primates, ungulates, and pigs), a defined geographic area (e.g., forest or non-forest polygons), or farms. A minimum sample size is required for an IE to have the power to assess causality, which depends on several factors, including the outcomes under investigation.

Quasi-experimental methods are more common for conservation and land, resource, and governance interventions. For evaluating forest condition outcomes, projects apply a matching approach to develop synthetic controls of forest pixels. For the evaluation of settlement and household level livelihoods, well-being, governance, and health outcomes, a quasi-experimental methodology can be applied in treatment and comparison areas. Comparison areas and settlements may be identified from non-activity areas, matched on key biophysical and human population characteristics.

PERFORMANCE AND MIXED-METHODS EVALUATIONS

PEs, as defined in Automated Directives System (ADS) 201, encompass a broad range of evaluation methods (see Appendix F for a more detailed discussion). They often incorporate before-after

[4] Non-experimental approaches can answer descriptive questions about differences but cannot measure causality with the same degree of rigor or confidence. Non-experimental approaches include PEs, which generally include before-after comparisons without a rigorously defined counterfactual, and case studies, which include in-depth learning from an instance through extensive description and analysis.

comparisons but generally lack a rigorously defined counterfactual. PEs may address descriptive, normative, and/or cause-and-effect questions.

A mixed-method evaluation integrates two or more evaluation methods, usually drawing on both quantitative and qualitative data. Mixed-method evaluations may use multiple designs, for example incorporating both DID quasi-experimental methods and rigorous longitudinal research. They may also include different data collection techniques such as structured observations, key informant interviews, household surveys, and reviews of existing secondary data. Mixed-methods designs can strengthen an evaluation by (1) using different methods to answer different evaluation questions, or (2) using different methods to answer the same questions (increasing confidence in the validity/reliability of results). Generally, mixed-methods evaluations can provide a deeper understanding of why change is/not occurring and can capture a wider range of perspectives.

IV. State of the Evidence

CONSERVATION AND BIODIVERSITY EVALUATIONS

There is a small but growing body of rigorous IEs on the effect of conservation policies and programs centered on natural climate solutions (NCS), such as payment for ecosystem services, protected areas, land titling, and forest restoration. In addition to NCS interventions, conservation organizations have made significant investments in alternative livelihoods and resource protection to incentivize behavioral changes to improve conservation and reduce threats to biodiversity. For these interventions, rigorous evidence for positive impacts on outcomes related to conservation and well-being is sparse. And, across the spectrum of conservation interventions, rigorous evidence on well-being and biodiversity is lacking from the current body of evidence.

Particularly, the impact of ecosystem restoration on zoonosis and spillover risk for vector-borne disease is of primary interest for USAID. There is no direct zoonosis or health programming as a result of RESTORE. However, the ecosystem restoration and conservation interventions are expected to have an effect on wildlife health and zoonosis outcomes. Thus, even absent direct programming, an IE of RESTORE provides a potential opportunity for rigorous learning around zoonosis and vector-borne disease. Below, we provide several values of a zoonoses IE[5] in addition to contributing to the current knowledge gap in evaluations.

Conservation employs a variety of interventions, usually implemented as a suite that spans three levels in line with the Conservation Measures Partnership taxonomy of conservation actions: (1) interventions to improve the enabling environment for conservation, (2) interventions to change behavior/mitigate the threat, and (3) actions to relieve direct stress on species and ecosystems through land/water and species management (Faust et al. 2023). Common USAID interventions include protected area management, conservation enterprises, law enforcement, demand reduction/behavior change campaigns, and strengthening enabling environments (legal/policy reform, conservation planning, education/training, institution strengthening), as well as more innovative market-based and direct economic payment schemes. Meta-analyses of IEs, which measure the causal impact of programs, have unsurprisingly not identified a silver-bullet strategy for ensuring conservation outcomes (Börner et al. 2020). Conservation programs typically include a bundle of interventions not easily disentangled, such as resource protection, habitat maintenance and restoration, and alternative animal sourced foods.

[5] A zoonosis IE can be interpreted as an extension of an IE of conservation, biodiversity, or wildlife demand reduction programs. For example, a well-designed and comprehensive zoonosis IE requires all of the data collection needed for a conservation or biodiversity IE – with the addition of wildlife and health data sources to examine additional outcomes. Thus, pursuing a zoonosis IE necessarily includes a conservation or biodiversity IE; the data required for zoonosis can be seen as a supplement to a planned conservation/biodiversity IEs. As part of a zoonosis IE, the research team will be conducting counterfactual research for a number of outcomes along the way, in addition to producing rigorous research to support knowledge on preventing zoonosis spillover.

There is significant variation in the rigor of studies about the effectiveness of conservation programming, and weaknesses have been well-documented in the literature. Many studies on the effectiveness of conservation strategies involve simple monitoring of indicators or case studies (Ferraro and Pattanayak 2006). To date, IEs are rare in conservation science; there are limited counterfactual-based studies that evaluate intervention effectiveness, and many are subject to a poor research design (Ribas et al. 2020; Burivalova et al. 2019). This is especially true for efforts to assess the effects of programming on both conservation and poverty reduction, with limited and methodologically weak efforts to assess poverty outcomes relative to measuring forest conditions (Samii et al. 2014). Strong evidence has a patchy geographic distribution, and many studies lack long term outcome measurements and/or focus on only a single outcome—forest cover change. Conservation programs have been biased towards locations facing relatively low threat levels and, by design, with high biodiversity value (Joppa and Pfaff 2009). This is problematic for understanding impacts in partially degraded landscapes with dynamic land-use change. It also indicates the opportunity to find larger conservation impacts in areas facing more degradation and deforestation pressures.

Although biodiversity outcomes remain significantly understudied, over the past ten years, the rigor of conservation evaluations to measure forest cover change has significantly improved (Baylis et al. 2016). This includes the increasing use of statistical matching techniques as a correction for selection bias, which occurs when there are pre-existing, systematic differences between participants and non-participants that introduce bias into study designs. However, more rigorous study designs such as matching combined with DIDs (which estimate impact by comparing changes in outcomes among program participants with changes in outcomes among non-participants), synthetic controls (which construct a weighted average of potential comparison units that best resembles the treated units), and RCTs (which use random assignment to ensure that those assigned to participate in the program are, on average, the same as those who are not) remain limited (Börner et al. 2020).

Counterfactual/causal studies have not been prioritized in the conservation space relative to other development sectors. Several challenges have been raised about conducting rigorous research in this sector. These center around concerns that measuring impacts on biodiversity and conservation is methodologically challenging and expensive (Ferraro 2009; Rissman and Smail 2015). Specifically, challenges include: a historical legacy of prior interventions; purposeful selection of treatment areas; hard-to-identify comparison areas; large variability in ecological outcomes; long time lags between intervention and ecological response; programs with multiple interventions; complex spillover effects (e.g., forest use, species movement); large spatial scales of environmental processes; and data constraints, including a heavy reliance on self-reported behavioral indicators.

Of particular concern are the challenges to collecting biodiversity data and indicators in the context of counterfactual designs. These generally relate to difficulties in finding valid control sites and the high costs for collecting a sufficiently large sample of biodiversity outcomes. Many studies have noted that biodiversity is difficult to measure in the context of a statistically robust approach, especially an approach that would be viable to use biodiversity as an impact measure in the context of an IE (Persha and Bui 2021; Meijaard et al. 2021). Population trends pre- and post-intervention for selected species across a sample of forests that receive the program, and a similar enough sample of comparison forests without the program, are required. Fundamentally, measuring biodiversity is a costly data problem, as it is time intensive and expensive to measure biodiversity through standard methods such as transect sampling and netting. Current data sources that provide measures of forest extent, deforestation, and land cover change do not necessarily provide good proxies for biodiversity measures, as forest cover does not indicate the presence/absence or diversity of species, poaching, etc. (Burivalova et al. 2019). Global and publicly available remotely sensed spatial data often cannot be mapped at the site level to directly measure local biodiversity for most species, even if they are available at a high frequency and at a small enough scale (Hill et al. 2019).

The lack of robust evidence makes it difficult to draw insights to inform future conservation efforts, and a number of studies over the past decade have emphasized the need for more rigorous experimental and quasi-experimental studies related to conservation outcomes (Curzon and Kontoleon 2016; Ribas et al. 2020). Many of the challenges outlined above are not unique to forest conservation and biodiversity IEs, but rather apply generally to IEs conducted in the international development sphere.

FOREST RESTORATION

The quantitative evidence on natural forest restoration outcomes, in general, is sparse, with particularly insufficient study to examine how social context affects the diversity and abundance of regenerating trees, and how this, in turn, influences ecosystem function and livelihood benefits (Chomba et al. 2020). To-date, there is no counterfactual evidence on the impact of restoration interventions on social or ecological outcomes. This makes it difficult to determine where and for whom forest restoration and similar nature-based solutions are an appropriate intervention technique.

Wildlife conservation through the protection and restoration of ecosystems has the potential to reduce zoonotic spillover (Sokolow et al. 2019; Reaser 2020; Plowright et al. 2021), but this concept has yet to be demonstrated on a large scale in a real- world setting. Data examining the outcomes of such efforts is currently absent, although reforestation or restoration are core components of many countries' climate change mitigation commitments. Only two studies focus on reforestation and zoonotic risk. The first study uses models and empirical field data to infer a 43 percent reduction in Hantavirus risk for 2.8 million people if Atlantic Forests were restored in Brazil. Models based on a cross-sectional survey of 104 sites across degraded and restored landscapes in the Brazilian Atlantic Forest suggest that native forest restoration could significantly reduce viral zoonotic risk from rodents (Prist et al. 2021). The second study examines Pumuula virus infection rates among voles in forests of different ages and shows that voles in immature forests (20-35 years) have higher infections compared voles in mature forests (>100 years) (Vaheri et al. 2013-01). Although these studies are limited in systems and scope, they emphasize that more data is required to understand the context and conditions where tree planting and/or restoration of forests could reduce zoonotic risk.

Overall, there is a significant knowledge gap in our understanding of whether and how development programs aimed at improving forest outcomes and biodiversity will impact the risk of viral zoonotic spillover. The implications for zoonotic risk are unclear with outcomes likely dependent on the type of reforestation and the resultant biodiversity species richness.

ON-FARM COCOA AGROFORESTRY

Cocoa agroforestry systems, relative to cocoa monocultures, have demonstrated success in increasing cocoa yields and productivity. Benefits provided by cocoa agroforestry systems include: improvement of pollination; long term cocoa yield; longer life span of cocoa plantations; control of pests and diseases; erosion control; biodiversification conservation enhancement; climate change mitigation through carbon sequestration; nutrient cycling; soil fertility maintenance or enhancement; watershed protection; and avoided deforestation (Niether et al. 2020; Castle et al. 2021).

However, cumulatively, the evidence available on the various impacts of cocoa agroforestry interventions is not extensive (Tolisano et al. 2022). Limited evidence makes it difficult to draw conclusions on the effect of different intervention types (Castle et al. 2021; Snilstveit et al. 2016). There are particularly significant research gaps in verifying the economic and financial analysis of agroforestry models, especially those affecting food security concerns of indigenous communities; additional research on nutrition, food security, and environmental outcomes is needed. Equity concerns of agroforestry interventions appear in many of the studies, with mixed results, indicating that additional consideration of equity in agroforestry interventions is needed. A recent review noted a particularly large knowledge gap on biodiversity conservation in cocoa agroforestry systems, as well as the incidence of pests and diseases (Tolisano et al. 2022).

Farmers' decisions to incorporate trees into their farmland were mainly influenced by a wide variety of factors, including: silvicultural knowledge and skills, participation in farmers' groups or other social organizations with an interest in tree conservation, the social value of biodiversity in the rural landscape, and the perceived economic benefits of trees on farmland. The main barrier in the adoption of agroforestry incentives cited by farmers was the long waiting time for the accrual of benefits of planting trees, which require several years to grow before providing benefits. Women-headed households were also often disproportionately affected or overlooked by agroforestry interventions, with some of the studies showing that women-headed households had less positive or more negative impacts on their households than male-headed households (Castle et al. 2021). Other key household and individual factors associated with variation in levels of motivation to conserve trees on farms included household wealth, gender, age, education level, marital status, residence status, farmland size, household size and technical support (Sanou et al. 2019).

TENURE SECURITY LINKAGES TO CONSERVATION OUTCOMES

Despite a widely held expectation that tenure security can improve incentives for conservation, counterfactual studies linking tenure security to conservation outcomes have been sparse (Tseng et al. 2021) and mixed (Lisher and Huntington 2023). This empirical literature has grown as donors have funded tenure reform programs in a variety of contexts that offer the opportunity to measure the effect of interventions to strengthen tenure on forest outcomes with quasi-experimental methods. Two different approaches to improved tenure are the focus for counterfactual studies: (1) individual registration and titling, and (2) strengthening communal property rights. Thus, it is important to distinguish between tenure security on de facto private land for both agricultural, investment, and conservation outcomes, as well as tenure security on community land or as part of a de facto common pool resource. The growing literature has found positive effects on forest cover on average, but results have varied widely by context (Tseng et al. 2021) and by the type of tenure under investigation (Robinson et al. 2014), leaving open the question of how the relationship between tenure and forests might be mediated by tenure form, context, geography, and institutional factors. The standard presumption in much of the economics literature on the relationship between tenure security and investment is that tenure security would encourage investments such as tree-planting, structures or soil conservation measures, since tenure provides assurance of this investment paying off (Besley and Ghatak 2010). This expectation appears to hold in some settings as with agricultural investment in Benin (Goldstein et al. 2018), and investment in urban dwellings in Peru (Field 2005). However, this expectation is complicated by the possibility that investment may itself be a way to assert tenure (Besley 1995).

According to common-pool resource (CPR) theory, insecure and poorly defined rights lead to overexploitation of common property resources, such as forests. Weak property rights encourage land-poor households to colonize frontier areas (Clark 2000; Oliveira 2008), and colonists can use weak property rights to make quick gains in productive activities versus investing in forests and other long-lived assets (Mendelsohn 1994, Barbier and Burgess 2001). CPR theory argues that improving property rights for indigenous territories can help to curb deforestation (Ostrom et al. 1990, Ostrom 2010, Dietz et al. 2014). Tenure security (de facto or de jure) helped to overcome collective action problems as part of community self-governance of CPRs.

Another key mechanism for improving CPR outcomes is to promote more effective management and collective action around shared resources. Core principles of effective management include clearly defined boundaries, collective management, recognition of rights to organize, effective monitoring systems, graduate sanctions, and conflict resolution mechanisms (Ostrom et al. 1990). Accordingly, the recognition of legal rights enables some CPR management requisites, and in the context of forest resources, monitoring and enforcement activities have proven to be productive in deterring deforestation (Assuncao et al. 2019; Fearnside 2017) and are necessary in providing tenure security to indigenous territories (Gebara 2018).

A growing body of research has examined the effectiveness of indigenous territories for preserving forests, through titling, management, and/or legal recognition. A number of studies have found a positive relationship between indigenous territories and forest preservation (Nolte et al. 2013; Soares-Filho et al. 2010; Bonilla- Mejia and Higuera-Mendieta 2019; Blackman et al. 2017; Liscow 2013; Nepstad 2006; Jusys 2018; Baragwanath and Bay 2020), whereas other studies find no effect (BenYishay et al. 2017; Buntaine et al. 2015).

In particular, a number of cross-sectional studies in Latin America that measure the effect of legal recognition and indigenous community management on PAs (Muller et al. 2012; Vergara-Aseno and Potvin 2014; Nelson et al. 2001; Nolte et al. 2013; Nelson and Chomitz 2011) find positive results for indigenous community management/stewardship. In contrast, Pfaff et al. (2014) did not find significant positive results. Studies that look at panel data to link indigenous communities and deforestation measure only the effect of formal legal recognition of pre-existing indigenous community management

(Blackman et al. 2017; Blackman 2018; Ben Yishay et al. 2017; Buntaine et al. 2015; Hargrave and Kis-Katos 2012). Results here are more mixed. If tenure security does indeed increase incentives for agricultural and land investments, this would explain differences in outcomes for forests in frontier areas and those in forest/agriculture mosaics. In settled mosaic landscapes, managing or planting trees represents an investment for landholders (Chomitz 2007), on the other hand, at the frontier, clearing land could represent an investment, as could patrolling forest area to enforce one's property claim. A related literature on incentives for engaging in agroforestry has tended to find that tree-planting in agricultural landscapes could be encouraged by secure tenure (Mercer 2004; Pattanayak et al. 2003), though an RCT testing this hypothesis showed no impact of perceived tenure security on agroforestry uptake (Huntington and Shenoy 2021). Nevertheless, the status of trees as investments in settled settings, but cleared land as an investment in the frontier, means that the relationship between tenure and forest at the frontier could be quite equivocal, while in settled areas we might expect a more positive relationship.

Further complications enter the picture if you consider the long-term returns of agricultural investment versus the returns to preserving forest cover. Liscow (2013) shows that in a discrete-choice model of land use, the sign of the effect of tenure security on deforestation is ambiguous since it increases the returns to both forest protection and agricultural investment. Thus, the link between tenure and deforestation likely depends on context, including the baseline security of tenure in each area under examination. As Liscow (2013) points out, the effect of changes in tenure security will depend on tenure security's effect on the relative profitability of forest land use versus agricultural land use. This relative profitability would depend on commodity prices, transport costs, input costs and the potential agricultural productivity of the land. Therefore, one would expect to see different impacts in different geographies.

The indeterminacy in expectations in the theoretical literature is born out in a review of empirical studies of the relationship between tenure security interventions and forest cover. Two meta-analyses find that improvements in tenure security and forest cover are mixed, but positive on average (Robinson et al. 2014; Tseng et al. 2021) and in many cases the reviewed studies rely on cross-sectional variation and assume that differences in tenure form (individual versus common property) reflect differences in tenure security (Robinson et al. 2014).

Our own review of the literature found seven studies based on quasi-experimental research methods linking tenure security interventions—both individual land registration efforts, and communal land recognition—to forest outcomes. Of these, four found a decrease, one found an increase, and two found no change in deforestation. Of the three studies examining demarcation and registration of communal lands, two saw no change, and one found less deforestation.

Overall, the mixed results from the literature are likely due to several factors, including type of tenure form under investigation (Robinson et al. 2014), differing definitions of tenure security, variation in research design (Huntington and Shenoy 2021) and the highly context-dependent nature of the causal chain linking tenure to environmental outcomes such as deforestation. Arnot (2011b) highlights the wide variety of definitions of tenure security, and therefore the diverse variables used to proxy for it in empirical studies. Meanwhile, in Africa, Fenske (2011) proposes that the link between changes in tenure status and development or environmental outcomes could be weak given that baseline traditional tenure arrangements tend to be relatively strong pre-intervention. A survey of tenure perceptions in four African countries supports this hypothesis (Huntington et al. n.d.).

RESTORE will have implications for both individual tenure security, through the on-farm tenure component, and common property tenure security through the off-farm governance activities. The evaluation design report will define the methods, mechanisms, and outcomes for each of these components.

ALTERNATIVE LIVELIHOODS

There is an absence of rigorous empirical evidence about the impact of alternative livelihood programs on conservation outcomes. To incentivize behavioral changes to improve conservation and reduce threats to biodiversity, conservation organizations have made significant investments in alternative livelihood initiatives including conservation enterprises and public-private partnerships to improve market linkages (Roe et al. 2015). However, rigorous evidence for positive impact on outcomes related to conservation, well-being and biodiversity is lacking. As a result, an evaluation of RESTORE would present an important opportunity for the first (or one of the first) counterfactual-based studies of alternative livelihood programming.

Studies have shown that direct participants have had more access to resources and benefits compared to neighbors and non-participating communities, although these increased livelihood and well-being benefits have not translated to changes in attitudes towards sustainable resource use (Maynard et al. 2021; Silva and Khatiwada 2014). Overall, studies show that despite extensive investment in alternative livelihood projects, the structure and results of most of these projects have not been documented in a way that facilitates rigorous evaluation and learning. Overall, there has been little post-project monitoring and no rigorous research designs tied to the analysis of outcomes or impacts (Roe et al. 2015).

ZOONOSES SPILLOVER RISK OF LAND USE CHANGE

Despite the potential for benefits, significant knowledge gaps exist with respect to the quantitative linkages between ecological restoration and human health benefits. This includes a limited understanding of the ecological and sociological drivers of zoonoses, as well as a dearth of studies on the influence of land use and biodiversity on zoonotic spillover risk. At present, no IEs have been completed on the effectiveness of interventions to mitigate the risk of zoonotic spillover.

There is a lack of empirical studies on (1) what interventions will most effectively support improved forest outcomes and biodiversity and (2) whether and how targeting those mechanisms will impact the risk of viral zoonotic spillover. These gaps limit our ability to estimate risk levels and act upon sound data and evidence. For example, as discussed above, restoration of native ecosystems, including forests, has been proposed to mitigate zoonotic spillover (Plowright et al. 2021). However, data examining the outcomes of such efforts is currently absent. Although reforestation or restoration are core components of many countries' climate change mitigation commitments, the implications for zoonotic risk are unclear with outcomes likely dependent on the type of reforestation and the resultant biodiversity species richness.

VALUE OF A ZOONOSES IE ADD-ON

Reducing zoonotic spillover is not the primary objective of the RESTORE intervention or IE; however, the RESTORE IE presents an opportunity to capitalize on the potential for additional learning about zoonosis in the context of forest restoration in a tropical area. The RESTORE IE presents an opportunity for a 'zoonosis add-on' through supplemental data collection on indicators of interest from a zoonosis standpoint.

The RESTORE evaluation is still in the design phase, thus, the extent of the data collection, final research design, and associated cost implications are yet to be determined. However, RESTORE provides an example of the potential for an IE of an intervention that is centered on improving conservation and biodiversity through forest restoration – but without a public health component. As described above, forest restoration could also benefit human health by increasing biodiversity (in particular species that do not amplify viral zoonotic risk), lowering disease prevalence in reservoir populations, and reducing reservoir host-human contacts and hazard.

The likelihood of RESTORE having an impact on zoonotic disease transmission through its impact on biodiversity and ecological health, and the likelihood of such impact occurring within the follow-up study time frame depends on the location and scale of selected off-farm restoration sites. The ET deems that the location and scale of the current off-farm planting sites planned by the IPs do not have the potential to impact biodiversity and human-wildlife interaction in a significant manner to have implications for zoonotic disease transmission. However, if off-farm activities increase in subsequent years to the extent that disease transmission may be affected, the study can be designed to capture changes in the prevalence of the most common zoonotic diseases (e.g., malaria) and disease carriers through social and ecological data collection. Below, we present the state of the evidence and value of a potential zoonosis IE.

MEASURING IMPACT

First, the main direct benefit of a zoonosis IE would be to assess the impact of a program on reducing the risk of zoonosis spillover and zoonosis risk factors. Longitudinal and counterfactual data is necessary to identify causal relationships between land-use conversion and disease emergence. Data collected in the context of an IE is based on an underlying research design (with a counterfactual) and often for a longitudinal time frame; this represents improved data sources to facilitate our understanding of the mechanisms by which viral zoonotic emergence occurs, and the effectiveness of interventions to mitigate that risk. IE data will allow us to understand the effectiveness of interventions to mitigate these risks.

The very process of subjecting a program to an IE has numerous benefits beyond the actual assessment of impact indicators, and these benefits begin accruing early in the process. Several benefits would accrue as part of the process of designing and implementing an IE. This includes a better designed program and M&E, along with baseline data to improve the adaptive management of the program. IEs add value by strengthening a program's TOC and connecting interventions to the evidence base during the feasibility stage. Baseline data can also challenge assumptions and promote more effective, adaptive programming.

In addition, as noted above, to achieve a zoonosis IE implies the evaluation of interventions that are designed to improve conservation and biodiversity outcomes. As noted above, there is very limited/no rigorous counterfactual evidence on many of these interventions – and improving conservation/biodiversity as part of climate change initiatives is a stated priority for many development donors. Thus, the pursuit of a zoonosis IE necessarily implies an expansion of counterfactual based studies of conservation, biodiversity, and/or wildlife demand reduction interventions. Many of these interventions link to United States Government (USG) priorities for climate change mitigation research and evaluation.

IMPROVED MITIGATION AND SURVEILLANCE EFFORTS

As noted in the data sources section (Section VI), a best-case scenario zoonosis IE would require a comprehensive amount of data, including integrated economic, sociological, and ecological data of the mechanisms facilitating zoonotic emergence. These data can feed into other ongoing mitigation and surveillance efforts that are occurring in/near the study area. If project and research geographies are prioritized where there is ongoing surveillance, then data collected through an IE can feed into these other efforts and vice-versa.

RISK MAPS

Baseline and follow-up data from IEs can feed into efforts to refine risk mapping and modelling at different spatial and temporal scales. Disease risk mapping often occurs at the two extremes of spatial scales: local and global. These risk maps can provide overly detailed information on one pathogen at a given point in time or provide general estimates on a much greater scale—neither of which are useful for informing policies nor programs. Risk maps focused on national (or higher) levels do not provide refined information at subnational or local levels—where planning and surveillance policies are actually implemented. Regional and local risk maps have the potential to more accurately identify high risk locations within a region. They can also enable targeted surveillance, educational activities and various governance, tenure, conservation, agricultural, and health interventions to prevent zoonosis. These risk maps could incorporate future land use planning and be used to mitigate risks posed by new infrastructure development. The collection of additional information to identify specific cultural practices and behaviors, such as wild animal hunting and meat supply chains, could greatly improve efforts at risk mapping. All of this would provide a valuable feedback loop; improved risk mapping would help better identify geographies to target for zoonotic surveillance and monitoring, which would support more targeted programming.

GENERAL RESEARCH

Beyond program impacts, IEs can shed light on a number of related research questions and provide data to help develop models to better quantify viral zoonotic risk in changing landscapes; this is essential to developing understanding associated spatio-temporal variation in risk factors measured by 1) human-wildlife contact, and the 2) likelihood of infection given a contact. A rigorous One Health research program—with longitudinal and counterfactual data—in focal regions would help identify key mechanisms affecting the emergence and establishment of zoonotic viruses in human populations that can be applied beyond a particular IE study area (Plowright et al. 2021). The collection of data that is highly beneficial for advancing our knowledge of zoonotic risk, independent of the IE objective. This data, along with evidence from the IE, will refine our understanding of which factors in what contexts drive zoonotic risk (Hassell et al. 2021). This would be a public service of improving general scientific knowledge. As described above, there is a significant knowledge gap across a number of research questions related to zoonotic spillover risk; data is lacking that enables nuanced zoonotic risk assessments within a number of target populations.

For example, although wild meat supply chains are often cited as major conduits of zoonotic risk, they may actually represent a more minor driver of spillover than landscape-level changes, such as deforestation and ecosystem fragmentation. Enhanced data collection on viral zoonotic risk could be applied to various points in wild meat supply chains and as part of efforts to combat wildlife trafficking. Quantification of the impact of efforts to reduce farming, hunting, butchering, transporting, and consuming wild meat will improve our understanding of the viral zoonotic risk posed by wildmeat supply chains. This includes understanding transmission routes and potential roles for contact with spillover risks for bushmeat hunters and traders.[6] Longitudinal serology and polymerase chain reaction (PCR) surveillance tests in a range of exposure contexts could show whether, for example, bushmeat traders who sell smoked or dried bushmeat exhibit lower risk levels at baseline compared to traders of live or freshly killed bushmeat or to traders of poultry or fish, and whether such risk levels decline over time in response to specific interventions. Such an effort could complement and coordinate with next generation immunological surveillance and metagenomics (Wille et al. 2021). A well-designed and long-term research agenda will improve understanding of how (and on what timescale) changes in host species richness, composition, and relative abundance impact disease prevalence.[7]

[6] This includes contact through mucosal surfaces (e.g., nose, lungs), exposure to wounds, or other contacts with feces, urine, and contamination of food should be explored.

[7] Theoretical work demonstrates that changes in host species community composition and relative abundance impacts disease prevalence (Faust et al. 2017; Mihaljevic et al. 2014; O'Regan et al. 2015), favoring increased disease risk in modified, low diversity landscapes. However, changes in host species richness and abundance may only have transient impacts on pathogen load, and over longer timescales these differences may not be important (Halliday et al. 2019).

V. Design Options

The FA team considered not only IEs, but a variety of evaluation approaches as part of the FA. This included (1) experimental approaches, which measure the causal impact of programs through randomization; (2) quasi-experimental, which also attempt to measure causal impacts but without randomization; and (3) non-experimental approaches, which can answer descriptive questions about differences but cannot measure causality with the same degree of rigor or confidence. Please see Appendix F for a more detailed discussion of evaluation methods.

At present, this assessment finds that the RESTORE Activity might be amenable to an evaluation design that includes mixed impact and PE elements. We separate the program activities into two components, one targeting on-farm area tree planting, regenerative agroforestry and conservation practices, and one targeting off-farm area tree planting and conservation, including currently planned active forest restoration in Ghana and boundary planting in CDI.

Ghana's off-farm restoration component in SA1 might be amenable to an IE through a quasi-experimental DID approach. The on-farm components and boundary planting, including activities under SA1 to 3, are amenable to assessment through PE and rigorous longitudinal research. Based on the information that the IPs provided, an on-farm cocoa agroforestry IE (SA3) is likely not feasible due to challenges to finding a valid and policy relevant comparison group. An IE of the on-farm tenure component (SA1) and LMBs (SA2) is also not feasible because of challenges related to the number of treated units for these components (five new villages for the tenure component and five LMBs). The alternative livelihood component of SA4 might be amenable to an IE pending more details on the recipient selection process to understand whether the selection of comparison group is feasible.

Many of USAID and RA/ofi's learning questions of interest about the effect of the on-farm cocoa agroforestry, tenure, LMBs and alternative livelihood components could be explored through a rigorous PE design. In contrast, an IE might be feasible for the off-farm restoration component. The off-farm component—even designed as a rigorous PE—provides a good learning opportunity given the lack of rigorous evaluations of off-farm restoration programs.

Table 1 below provides an overview of potential evaluation approaches mapped to each program SA.

Table 1. Overview of Potential Evaluation Approaches Mapped to Each Program Strategic Approach

Strategic Approach	Intervention sites	Potential Evaluation Method(s)
SA1: Tenure and tree planting	On-farm, off-farm boundary planting	PE; Case study
	Off-farm active restoration	Difference-in-Difference (IE)
SA2: Land Management Boards	LMBs, On-farm	PE
	LMBs, Off-farm	PE
SA3: Regenerative agriculture / Cocoa agroforestry	On-farm	PE
SA4: Alternative livelihood	On-farm	Performance/ Matching or Difference-in-Difference (IE)

ON-FARM AREA EVALUATION METHODS

COCOA AGROFORESTRY AND RENEGERATIVE AGRICULTURE

We have a sufficient sample size of treatment units for an IE for this component (54 communities in Ghana and 49 in CDI). The primary limitation to conducting an IE of the on-farm cocoa agroforestry component is the lack of a viable comparison group. Since RESTORE is administered through farmer cooperatives, an IE would ideally draw a comparison group from other farmer cooperatives in the area. However, since all farmer cooperatives in the area comply with similar sustainability criteria, including requirements for the planting of on-farm agroforestry trees, it is unlikely that we can find cooperatives that do not receive some form of agroforestry program.

We explored comparing other agroforestry models to RA/ofi's model. Based on conversations with the IPs, we were not able to identify other agroforestry programs that are sufficiently different from the RA/ofi model to warrant the cost of an IE. However, in the scoping we considered the possibility of using new cooperatives, who have not had any agroforestry trainings, that will enroll into ofi's Sustainability program as a comparison group for the learning questions of interest. However, actual feasibility needs to be evaluated pending more information on numbers and location of the villages that these cooperatives cover.

Another group that could be considered is farmer groups or traditional cocoa farmers who are not involved in cooperatives and are not receiving on-farm cocoa agroforestry support. This would enable an analysis of outcomes for the RA/ofi on-farm cocoa agroforestry component in comparison to farmers who are not receiving on-farm cocoa agroforestry support. However, this choice of comparison group assumes that there are sufficient bodies of farmers in the study area that do not belong to a cooperative, and that these farmers are qualitatively similar to cooperative farmers to serve as a comparison group. However, we found from the scoping trip that this is not the case.

TENURE COMPONENT

In CDI, AFOR, the agency implementing the tenure assistance program, is already present in most villages (all but five) and at non-uniform stages of programming. RESTORE is only funding their activity in these five villages. This means that we would not have a baseline of comparable villages without any tenure assistance. However, we could design a rigorous PE that explores how variations across level of tenure security (villages at different stages of AFOR programming and farmers under different types of land tenure) across communities is associated with on-farm planting adoption rates (49 RESTORE villages). The evaluation would explore variations in conservation and livelihood outcomes within the treatment groups based on these contextual tenure variations. The evaluation would also explore differences between treatment and comparison areas on these tenure dynamics. If the scoping trip reveals that there may be villages in non-ofi cooperative areas which AFOR intends to intervene in if funding becomes available, then these villages could potentially serve as comparison groups for a PE. However, the ET is still assessing the number of locations of villages with this characteristic to understand the feasibility of this potential comparison group.

RESTORE informed the ET that tree registration and validation will occur in the Sui River Landscape or Sefwi Wiawso/Bibiani HIA in Ghana. USAID has dedicated research and evaluation funds to understanding the impact of tree registration in other studies. As a result, USAID will not dedicate resources to a purposeful evaluation of tree registration in the context of RESTORE, and the ET will aim to identify study areas that are not receiving the tree registration component. However, in cases where overlap between study communities and tree registration is unavoidable, the RESTORE evaluation will need to consider the interaction of tree registration activities with the activities of focus for the evaluation. We will need to take these registration activities into account and analyze whether there are heterogenous effects in areas receiving this intervention.

ALTERNATIVE LIVELIHOOD COMPONENT

The IPs list 20 communities and an estimated 20 households in each community as their target of participants to receive the alternative livelihoods component for a total of 400 individual recipients. This support will be spread across the full project timeline, although the workplan indicates that the selection of communities for this component will be completed by January 2023. Because the recipient selection process was still undefined, the FA team was not able to determine whether it is feasible to find valid comparison households/ groups in the same or similar treatment communities, and whether it is feasible to identify these household/ groups in the sampling design or through matching techniques. Selection of comparison households in the same community can allow us to assess household level impacts of the alternative livelihood component, assessing its marginal effect on household-level conservation practices by comparing recipient households to households in the same community who only received the agroforestry and tenure assistance. Selection of comparison households in similar treatment communities allows us to assess possible higher-level effects at the community level, where program effect on alternative livelihood options and perception of land-use may spill-over onto non-recipient households. Another objective of the scoping trip is to understand who are the recipients that are selected, how they were selected, and the characteristics of the communities they live in, to understand the feasibility of identifying comparison households.

A secondary consideration is the power of the research design. The power calculations (discussed in Section VII) indicate a weakly powered study to detect treatment and control group differences, if this component is implemented as a clustered design (treating each SME as a cluster), or a moderately powered study if we determine that the treatment unit is the household. The scoping trip and final implementation plan are needed to determine this.

OFF-FARM AREA EVALUATION METHODS

For evaluating forest condition outcomes and subsequent impact on biodiversity and zoonotic disease risks, we propose to apply a matching approach to develop synthetic controls of forest pixels. For the evaluation of settlement and household level livelihoods, well-being, governance, and health outcomes, this quasi-experimental methodology can be applied in treatment and comparison areas. Comparison forest areas and settlements may be identified from non-activity areas, matched on key biophysical and human population characteristics, once the off-farm planting area are identified.

At present, the conservation and biodiversity indicators for the off-farm forest restoration activity are anticipated to be amenable to an IE through a quasi-experimental DID analysis.[8] The data collection in sites with ongoing forest restoration and paired comparison sites without restoration efforts would provide essential data for understanding the effectiveness of forest restoration.

ILLUSTRATIVE RESEARCH DESIGNS

The RESTORE off-farm planting areas overlap with the villages where there is RESTORE on-farm cocoa-agroforestry programming. Thus, we can combine the data collection for an IE of the off-farm component with a PE for the on-farm components. We would have a subset of indicators and outcomes that would be collected from the same communities, and these outcomes will be analyzed as impact indicators to inform the off-farm restoration IE, along with a set of indicators and outcomes from the data collection that would provide evidence of performance/associations for the on-farm activities.

We would utilize an overarching quasi-experimental design for the off-farm component. The treatment area would be RESTORE reforestation areas. Comparison areas would be similar landscapes/forest areas to the RESTORE restoration areas that are not receiving a forest restoration program.

The main data sources for the forest restoration component would include human data collection from communities near/accessible to the forest restoration sites, satellite imagery to measure forest cover loss and gain, and biophysical measures of biodiversity and forest degradation.

[8] Please refer to Appendix F for additional information on IE methods.

We would target the community level data collection to cover (1) areas relevant for the off-farm IE (bordering and/or with direct programming of the off-farm activities), (2) the 5 AFOR villages for the tenure component + stratification across villages on the status of AFOR program for village demarcation, as well as (3) the 20 villages that will be the target of the alternative livelihood/VSLA programming.

Human data collection would occur in a sample of the communities near/bordering these restoration sites where on-farm cocoa agroforestry work is taking place, out of the 75 treatment communities in Ghana (assuming restoration work in that landscape), and the 117 treatment communities in CDI (again assuming restoration work in all three CDI landscapes). Correspondingly, we would aim to collect data from comparison communities of the same sample size.

As part of a PE, an analysis of indicators and outcomes within and across treatment areas would be more valuable for answering RA/ofi's learning questions about the effectiveness of on-farm cocoa agroforestry, tenure strengthening, and LMB participatory governance components. For example, the evaluation would examine variation in outcomes based on variation in the progress of AFOR's tenure work across the study area as well as LMB participatory practices and structures. We would also provide an in-depth case study of the 5 villages slated for AFOR's entrance, and as mentioned above, we would examine how variation in tenure status and perceived tenure security at baseline across all treatment communities' moderate treatment effects. For the LMBs, in addition to household level information, we will conduct Key Informant Interviews (KIIs) to understand and compare the governance structure and capacity across the LMBs. We will also use household surveys in on-farm and off-farm communities to understand the extent of participatory governance and its association with outcomes. Also, as noted above, a supplemental comparison group of traditional farmers and/or farmer groups not involved in farmer cooperatives would provide some indication of the effectiveness of the cocoa-agroforestry model on the outcomes listed in Section VIII relative to traditional farming practices.

For the VSLA/alternative livelihood component, we would ideally seek two comparison groups: one within RESTORE's project area and one in the comparison set of on-farm communities. Ideally, within the RESTORE treatment area, we can identify comparison communities or households within VSLA treatment communities in collaboration with RA/ofi, either through randomization or a matching procedure.

Overall, this research plan would enable a quasi-experimental DID design for the off-farm component, along with a rigorous PE of the cocoa agroforestry, tenure, and LMB components, and an IE of the alternative livelihood component pending more information on VSLA recipient selection.

The ideal sample selection would be as follows:

Table 2. *Sample Selection*

Community/ Site type	Sample selection
Ghana treatment area (communities with both on-farm and off-farm interventions)	Data collection in a total of approximately 50 ofi communities, approximately 12-15 households per settlement. If there are any households that have been 'pre-identified' for the alternative livelihoods component, we would ensure that these households are targeted for the data collection.
Ghana comparison area for on-farm intervention	The comparison communities would include a set of traditional farmers and/or farmer groups outside of the cooperative system (pending information to be identified in the scoping trip as discussed above). We would collect data in approximately 50 of these comparison communities, with approximately 12-15 households per settlement.
Ghana comparison area for off-farm intervention	It seems unlikely that the on-farm comparison areas would overlap with a viable comparison area for the off-farm forest restoration component. If these do not overlap, we would need to consider data collection for off-farm comparison communities in another location. For the off-farm comparison groups, since RESTORE is focused on farmer cooperatives, we could aim to identify similar farmer cooperatives that are located near similar forest landscapes. If we are aiming for an IE, we would want this sample to include approximately 50 communities.
CDI treatment area (communities with both on-farm and off-farm boundary planting interventions)	Data collection in a total of 50 communities, approximately 12-15 households per settlement. This would include the tenure and alternative livelihood villages, and we would ensure that households targeted for the alternative livelihoods components are sampled in the survey.
CDI comparison area for on-farm and boundary planting intervention	The comparison communities would include a set of traditional farmers and/or farmer groups outside of the cooperative system, in an area where AFOR is likely to expand their work into if funding allows. We would collect data in approximately 50 of these comparison communities, with approximately 12-15 households per settlement.

VI. Illustrative Outcomes, Potential Data Sources

This section describes illustrative social, ecological, and social-ecological linkage outcomes for both on-farm and off-farm portion of the intervention and describes potential data sources. Appendix A presents a summary of indicators across outcome areas and proposed data sources that will be important to include in M&E based on the program's TOC. A comprehensive IE to measure outcomes related to conservation, biodiversity and zoonosis will need to take into consideration measures for forest condition, biodiversity, wildlife health, and human health. The subsequent subsection elaborates on each outcome area.

HUMAN AND SOCIAL DATA COLLECTION

Table 3 below includes illustrative human well-being outcomes for the RESTORE Activity. For more details on the potential indicators, please reference the detailed guidance and Performance Indicator References Sheets in the HEARTH M&E Toolkit Guidance document. These indicators are not linked to any one SA, but rather are anticipated to be relevant across the RESTORE Activity project areas and interventions. It is anticipated that all indicators below would be measured through household surveys.

Table 3*. Illustrative List of Human and Social Outcomes and Indicators*

Outcome Type	Illustrative Outcomes	Potential Indicators
Food Security and Nutrition	Dietary diversity	Percent of women of reproductive age consuming a diet of minimum diversity (MDD-W)
	Improved individual or household food security	Percent of households experiencing moderate and severe food insecurity, based on the Food Insecurity Experience Scale
	Reduction of potential exposure to zoonotic diseases	Percent of households consuming high-risk wild meat in the past year
Health	Health	Percent of children under five with diarrhea in the past two weeks
Conservation Knowledge, Attitudes, and Practices	Improved knowledge and attitudes towards conservation and natural resource management	Average score measuring the perceived importance of protecting nature and the environment
	Reduced unsustainable use of resources	Percent of households who engaged in unsustainable use of ecosystem resources in the past year; percent of households that cleared land for cultivation in the past year

Outcome Type	Illustrative Outcomes	Potential Indicators
Governance	Access and use rights	Indicators for household understanding of boundaries, perception of right to use and access forests
	Locally derived rules	Household reports of local/community rules around forest use and management
	Participatory decision-making	Household and community leader reports of involvement in local natural resource decision-making
	Effective monitoring	Household and leader reports of monitoring for rule breaking around forest use and access
	Graduated sanctions	Household and leader reports of differential sanctioning for varying levels of rule breakage
	Effective local conflict resolution	Household satisfaction and confidence in local conflict resolution
Collective Action	Trust	Perceived level of trust in daily activities among community members
	Intergroup relations	Levels of conflict within and across communities and subgroups within communities (such as different ethnic groups)
	Participation	Levels of participation in community decision-making
Agriculture and Land	Increased agricultural productivity	Average cocoa crop yield
	Increased use of sustainable/ regenerative practices	Number of hectares of cocoa under improved management practices or technologies
Resilience	Increased household resilience	Average score on the ability to recover from shocks and stresses index
	Use of natural resources to reduce effects of shocks and stresses	Average score measuring the extent that households rely on natural resources during times of stress
Socio-economic Well-being	Increased socio-economic status	Percent of households below the comparative threshold for the poorest quintile of the Asset-Based Comparative Wealth Index
		Change in per capita household consumption/expenditures in key areas such as health, education, etc.
	Women's empowerment	Percent of women achieving high empowerment on the survey-based women's empowerment index (SWPER)
	Increased benefits from alternative livelihood activities	Average household income from nature-based products and/or services

MEASURING FOREST CONDITION AND CARBON EMISSIONS

FOREST CONDITION

Deforestation rates are the most common standard for evaluating forest conservation interventions (Luintel et al. 2018). The FA team proposes using remote-sensing data to measure changes in tree cover, which are important indicators for habitat condition in addition to being proxies for biodiversity. Outcomes of interest for measuring forest condition include: Deforestation (forest loss); Forest loss/deforestation alerts; Forest degradation; Habitat connectivity; Land Cover Type; Normalized Difference Vegetation Index; and Burned Area.

Remotely sensed data is the primary data source for exploring the impact of the program on deforestation and degradation outcomes. This will include two types of available raster satellite imagery.

PUBLICLY AVAILABLE SPATIAL DATA

This data has been used extensively to examine the impact of major deforestation events such as fires, infrastructure, and large-scale land clearing. A number of academic studies employ geospatial IEs that use deforestation raster data to measure the impact of interventions on deforestation. Note that this data only allows the analysis of “forest loss" as opposed to the forest gain that we expect to find in the reforestation areas.

- Global Forest Watch Radar for Detecting Deforestation (Near real time data from January 2020, 10-meter resolution).
- University of Maryland Global Forest Change Data: Spatial units of forest loss (Annual data from 2000, 30-meter resolution).
- NASA/MODIS land cover and related products (Annual data from 2001, 250-500 meter resolution).[9]

UNPROCESSED IMAGERY THAT IS AVAILABLE TO THE USG THROUGH AN AGREEMENT WITH DIGITAL GLOBE:

This data can be used to explore crown cover and forest gain:

- High-resolution satellite data obtained from Maxar’s Global Enhanced GEOINT Delivery (G-EGD) via a license provided by the US Government. These images are at 0.3-meter resolution and are available annually from 2019.

[9] Note that given the low resolution of this data – it would be a secondary data source for the evaluation. We would rely more heavily on the high-resolution data sources.

FOREST PLOT SAMPLING (FOREST CARBON AND 3D FOREST STRUCTURE)

As a best practice for measuring forest quality and carbon emissions, we recommend the use of forest plot data and terrestrial lidar scanner imagery to map forest cover and biomass across treatment and control landscapes. This can also be used to measure carbon stocks in the study areas.

Assuming that we can establish a collaborative arrangement with the Poulsen Ecology Lab at Duke University, the evaluation can also measure the tree plots using a Reigl VZ-400i terrestrial lidar scanner that enables rapid 3D mapping of ecosystem structure (O'Sullivan et al. 2021; Calders et al. 2020), vastly increasing accuracy of direct volume and derived carbon estimates.

This methodology would require establishing a minimum of 60 tree plots (following methods used in Pelletier et al. 2017) and measuring the diameter and heights of all trees, from which the evaluation can derive estimates of forest carbon using allometric equations that relate tree measurements to tree biomass (Poulsen et al. 2020). Most of the allometric equations are valid in forests of different forest types with a well-defined annual rainfall (Pearson et al. 2005; Chave et al. 2014). Depending on the proximity of the off-farm restoration sites to agroforestry systems based on cocoa trees, and whether the IE includes ecological assessment of on-farm planting, other allometric models will be used to estimate the aerial plant biomass near and on cocoa dominant landscapes.[10] Measures for survival rate, crown width, and mean height would be assessed across species at baseline, 2 years after planting, and 7-8 years after planting.

In regard to the sampling of tree plots, we propose methods used during the National Forest and Fauna Inventory of CDI (IGN FI 2021). Inside each of the habitats, square-shaped plots will be arranged randomly. Thereby, four Sampling Units (SUs) of 50 m x 50 m will be placed. In these UE, 4 Rectangular Spaces (PR) of 25 m x 25 m (625 m^2) will be arranged. Inside each PR plot of 625 m^2, all woody tree individuals whose dbh is greater than or equal to 5 cm will be counted, measured, and identified. In the PR plots, square sub-plots (SPC) of 25 m^2 (5 m x 5 m) will be placed and will be used for the inventory of regeneration stems with a diameter of less than 5 cm (SPC of 25 m^2).

SOIL CARBON

Increasing soil organic carbon is important for agricultural resilience and productivity as well as reducing greenhouse gas emissions, and there are low-cost methods to quantify it based on integrating soil carbon and remote sensing data. Budget permitting, the evaluation can consider soil carbon sampling within each of the forest plots (Wade et al. 2019).

The soil survey approach proposed is soil pedon profiling and laboratory analysis of the soil samples. In each of the 60 forest plots of about 1 hectare each, five points on this portion will be chosen to open soil pits, one at each corner (northeast, northwest, southeast and southwest) and one in the center. The

[10] Species-specific allometric equations exist and will be used to estimate their biomass. For cocoa trees, the equation of Ségura et al. (2005) will be used for diameters between 1.3 cm and 26.8 cm. For the biomass of palm trees (raffia, coconut, rônier, and oil palm), the equation of Brown (1997) will be used. In banana and coffee plants, the equations of Hairiah et al. (2010) will serve as a basis for calculations.

pits will be described according to the horizons (FAO 2006) by identifying the color, structure, density and aspect of roots, abundance of organic matter, presence or not of coarse elements and their respective nature, porosity, biological activity, as well as the presence of carbonates (HCl test 10 percent).

For each profile, a systematic sampling will be done. Soil samples of approximately 500 g will be taken from the top to the bottom of each profile, over a vertical extent of 10 cm, in order to identify possible variations of the different soil characteristics with depth. The samples will therefore come from the following depths: 0 - 10 cm; 10 - 20 cm; 20 - 30 cm; 30 - 40 cm; 40 - 50 cm; 50 - 60 cm; 60 - 70 cm and 70 - 80 cm. From each depth slice, soil cores of 100 cm3 volume, three per slice, will be taken with a cylinder to determine the dry average bulk density (da).

Soil carbon stocks will be calculated by multiplying the proportion of organic carbon (percent C divided by 100) by the depth, bulk density (da), and proportion of coarse fragments in the soil (fragments larger than 2 mm in diameter) in the soil depth in question (Poeplau et al. 2015). Details of laboratory analysis of soil organic carbon storage, granulometry, and pH are included in Appendix H.

GREENHOUSE GAS (GHG) EMISSIONS

GHG emissions, estimated in metric tons of CO2 equivalent, reduced, sequestered, or avoided is one of USAID's standard indicators, and is important for slowing the rate of climate change and reducing its impacts. There are several options for measurement, including USAID's Agriculture, Forestry, and Other Land Use Carbon Calculator, or machine learning model estimation based on satellite and lidar datasets.[11] A variety of approaches using Random Forest machine learning models (Johnson and Abdelfattah 2018) combine airborne lidar data and satellite imagery to estimate top-of-canopy height, above-ground carbon stock, and forest cover change classification (Walker et al. 2020; Baccini et al. 2017; Csillik et al. 2019). Harris et al. (2021) also provide global satellite-imagery based forest carbon flux data, including emissions and removals. This dataset is currently available for years 2001 to 2019, but is designed to be updated as new data becomes available.

BIODIVERSITY

Forests provide important structure, shade, microhabitats, and food resources to a number of animal species, and thus habitat loss and particularly forest loss is an important driver of biodiversity loss. Increasing the total extent of natural ecosystems on target landscapes is a primary biophysical outcome of interest for the RESTORE Activity.

For biodiversity, direct measures are often moderately expensive, time-intensive and (in some species or methodologies) require specialist identification, technical or analytical skills. Nonetheless, they provide valuable information on species abundances, distributions, and behavior. Indirect measures using

[11] GCC standard indicator reporting templates. Global Climate Change. (2019, October 7). Retrieved from https://www.climatelinks.org/resources/gcc-standard-indicator-reporting-templates

remotely sensed satellite data only provide correlates of biodiversity and might cover large spatial extents that are too large to be useful for the RESTORE Activity.

Direct measurement of on-farm and off-farm biodiversity are key interests for USAID. The FA team understands the following as potential outcomes of interest given the proposed interventions for the RESTORE Activity: (1) recovery of on-farm and off-farm habitat and fragmentation, and (2) reduction of negative impacts on wildlife, in particular with respect to measuring outcomes for primates, rodents, and bats that might be linked to zoonotic spillover risk. Choosing the type of method to monitor species depends on the time and resources available, appropriate spatial scale for sampling, and types of species being monitored.

The global HEARTH MERL toolkit recommends monitoring changes in species presence/absence across study areas, as well as tracking changes in the population abundance in target species. Presence-absence data help to address simple questions, such as 'is this species present in the target area?' while abundance data address questions about trends, such as 'is this population increasing or declining, and at what rate?'. Aggregating species presence-absence data over multiple species can give an overall picture of species diversity (as a measure of species richness). However, presence-absence and abundance data can only provide limited insights into biodiversity distribution and trends. Wide-ranging or rare species are difficult to detect, so observed absences of species may not reflect true absences in a particular area. Further, demographic, or spatial, responses of many species occur too slowly to see significant changes over the lifespan of a project—except when a population is rapidly declining.

As part of the RESTORE Activity, the IP will not be collecting monitoring data on biodiversity measures. The evaluation will need to collect all of the data sources necessary for measuring biodiversity in an IE framework. Therefore, the extent of data sources will need to be balanced with budget and rigor considerations.

BIODIVERSITY OUTCOMES OF INTEREST

- Species Diversity (alpha diversity – number of species within an area)
  - Species richness (number of species within an area)
  - Species abundance (relative abundance of species within an area)
    - alpha diversity – number of species within an area
    - beta diversity – unique species across communities
    - gamma diversity – total species across areas
- Genetic Diversity – refers to the biological diversity within species that allows them to adapt to changes in climate and habitat, including helping to protect them against disease. At present, this is very expensive to collect.

BIODIVERSITY MEASUREMENT

Depending on context and budget considerations, a number of approaches have been put forward for measuring biodiversity. These include: proxy or predictive measures; satellite imagery to count sufficiently large wildlife that can be viewed from satellites (e.g., elephants); direct observation of species abundance; measurement through camera traps; eco-acoustics; and environmental DNA.

For the RESTORE Activity, the satellite imagery sources listed above for measuring deforestation and forest degradation are not suitable for analyzing key biodiversity outcomes, such as species richness and abundance. Direct observation is an option for the RESTORE evaluation, although with the qualification that it is time intensive and requires costly labor. Camera trapping outperforms direct observation and might be a viable method for measuring biodiversity as part of a RESTORE IE.

An IE of biodiversity programming requires a credible comparison/counterfactual area. This will require finding areas/landscapes that are ecologically similar to the areas where RESTORE interventions are being implemented. Baseline biodiversity data should be collected in treatment and comparison areas prior to intervention activities. Table 4 provides a summary of biodiversity measurement approaches.

***Table 4**. Summary of Biodiversity Measurement Approaches*

Method	Tools Required	Considerations for Monitoring
Ground-based transects/point samplings/plot of visual sightings and spoor	Species identification guides, binoculars, surveying equipment (depending on species and ecosystem), data collection devices (notepads, tablets, phones, etc.)	This can be designed to collect data in a rigorous manner, but it is a time-intensive (e.g., time spent making observations, surveying transects), method to survey plant and animal species. It is especially useful in that it provides a controlled spatial and temporal scale of observation with both recorded presence and absences of species. Requires skilled personnel who can accurately identify multiple species. Spoor baseline surveys involve walking transects to sight signs of animals (such as footprints, tracks, etc.), rather than the animals themselves, from various species and allow a coarse measure of relative abundance/density.[12]
Tools to remotely track animal movements Existing Source: Panthera GPS collars	Different types of technical options for tracking movements of wildlife across protected area boundaries. Physical tagging (e.g., GPS collars).	Provides rich information about individual-level patterns of movement (e.g., degree of connectivity between areas), changes in behavior (e.g., avoidance of human infrastructure or protected area boundaries), patterns of habitat use (e.g., preference for forest versus grassland sites), conflict behaviors (e.g., pattern of crop-raiding or livestock interaction from carnivores). This method might be feasible given that RESTORE is not occurring over a huge spatial scale. Detection of changes in movement over the course of the program would only realistically be feasible with large sample sizes and large numbers of dispersing individuals.
Camera trapping	Camera traps, security locks and cases, lithium	Camera traps are a standard method for monitoring a variety of species over large areas. Camera traps can be useful for

[12] "Research Findings on the Accuracy of Spoor Surveys as a Method of Calculating Carnivore Populations," *Wild Conservation Research Unit*, 2020, https://www.wildcru.org/news/research-findings-on-the-accuracy-of-spoor-surveys-as-a-method-of-calculating-carnivore-populations/.

Method	Tools Required	Considerations for Monitoring
Existing Source: Panthera camera traps	batteries, data storage cards, computing software for analyzing data	tracking presence/absence, and relative density of a wide range of species (large mammals, ground birds, cryptic or nocturnal species, species that can be attracted to baits (e.g., carnivores, small mammals), with little disturbance to habitat. Recently developed analytical tools to automated species detection/counts in images using machine learning classification can greatly reduce image processing time. The cost of camera trapping depends on the number and arrangement of cameras. However, cameras can be easily damaged or stolen when deployed in remote areas, so may be less suitable in areas with low resource protection or high fire frequency. Suffers from relatively frequent damage by wildlife (e.g., elephants and insects).
Collection and synthesis of existing data	Species occurrence databases including historical data, expert curated species distribution maps, existing research, spatial distribution modeling	Relies on existing data and reduces cost for additional data collection, however, insights are usually limited to a coarser spatial resolution and may be prone to missing data and gaps depending on how well the species in question has been documented and how reliable the existing data are (e.g., publicly contributed data may have species identification issues).

PROXY OR PREDICTIVE MEASURES

Proxy or predictive measures are better suited to estimate biodiversity impacts when deforestation, fragmentation, and loss of habitat connectivity are major threats to biodiversity. Proxy and predictive approaches require the assumption that reduced deforestation and improved habitat connectivity translate to improved biodiversity. Proxy measurements of species diversity and abundance can be applied based on forest loss.[13]

Global Forest Watch (GFW) maintains and reports two measures at 1 km resolution for global biodiversity intactness and global biodiversity significance. GFW has two layers - one for biodiversity importance and one for biodiversity intactness. The biodiversity intactness layer is based on the Projecting Responses of Ecological Diversity in Changing Terrestrial Systems database (Hudson et al. 2017). It provides a measure for how close the current ecological community is to its natural state, prior to any human disturbance. The biodiversity importance layer uses species range data from the International Union for Conservation of Nature (IUCN) Red List. The range data measures, for each pixel, the number of overlapping species ranges and the proportion of the global range that any specific pixel represents. Areas that are home to many common species or very rare species would have a high rating. This is low resolution data and only shows changes over relatively large areas. Thus, given RESTORE's spatial scale, these measures might be too blunt for the study area.

[13] This evaluation does not believe that resources should be used on a predictive approach, such as the method used by (Heilmayr, 2020) to model the biodiversity impacts of forest gains and improved habitat connectivity. Those resources for labor and technical expertise are better suited to camera traps.

As a more qualitative approach, we could consider using the IUCN approach to creating a counterfactual scenario. This would involve KIIs and structured interviews with group of experts to evaluate the state of different species in each spatial unit before and after the start of intervention using the IUCN Red List of Threatened Species. This has not been used to evaluate a conservation intervention.

DIRECT OBSERVATION

Observational wildlife surveys (both opportunistic and line-transect-based) can be used to document the diversity and abundance of relevant species, in the forest interior and on the forest edge. It can focus on indicators or sentinel species that serve as proxies for the condition of the overall landscape. Direct observation methods capture data through live trapping of wildlife and/or observation of indicator species through transect or quadrant walks. These methods involve trained enumerators regularly walking a line/transect or quadrant and/or routinely monitoring a live trap (Albornoz et al. 2022). Transect walks would support data collection across biodiversity and zoonosis outcomes.

CAMERA TRAPPING

Camera traps are set for long time periods and monitored periodically for maintenance and to recover photos. Photos are analyzed with machine learning techniques. Camera traps are good for measuring abundance of animals with markings that allow for individual identification.

There is a minimum recommended number of camera-trap nights required for reliable measures (Ahumada et al. 2020). Sampling intensity (i.e., number of trap nights) has been demonstrated to be the prime determinant of survey success, more so than camera spacing and grid size (Tobler et al. 2008).[14] This method is suitable only if there are pre/post species inventories of medium/large terrestrial species and/or the presence/absence of indicator species, which is the case for RESTORE. This method can also account for transient species.

ENVIRONMENTAL DNA (eDNA)

eDNA methods sample soil, sediment, water and identify genetic material (hair, feces, urine, etc.) from species present in the ecosystem. The genetic material is referenced against DNA databases to identify species present in the ecosystem. eDNA can be used to examine presence/absence of species, species richness, and species biomass. There are four stages: sampling, DNA extraction, processing of molecules, and DNA sequencing. This approach requires reference sequences, laboratories, and highly trained researchers.

[14] Tobler et al. (2008) found that 1,5000 trap nights (i.e., 50 camera trap stations for 30 trap-nights each) was sufficient to detect upwards of 80 percent of all known medium and large terrestrial mammals in a 50km2 site in the Peruvian Amazon.

The genetic material is referenced against DNA databases to identify species present in the ecosystem. Thus, this method is only feasible if there are established species in an established geography, along with access to laboratories and highly trained researchers. In cases where all of the requirements are in-place, eDNA methods represent a top performing method for detecting rare species, species richness, and species biomass.

Given cost and context considerations, among these approaches, the FA team recommends focusing on (1) camera traps and (2) direct observation through line-transect based walks for off-farm biodiversity IE. For on-farm biodiversity, we recommend integrating ethnozoological surveys into the social survey.

MEASURING THE LINKAGES BETWEEN HUMAN HEALTH AND ECOSYSTEM HEALTH

HEALTH SURVEY MODULE

To explore the links between ecosystem health and human health, along with zoonosis indicators, in each of the study villages, we will administer an in-depth health survey module to 5-10 families that include at least one child under the age of 15. Survey measures will include information on the incidences of water-borne illnesses and malaria, as a vector-borne disease.

BLOOD SPOT SAMPLING

Among the families who receive the additional health module, we would capture blood spots.

WATER QUALITY SAMPLING

The evaluation can explore the possibility of measuring water quality at baseline, endline and follow-up. Budget permitting, we will aim for additional rounds. Water would be sampled from the water body nearest each village following standard methodologies. For a good understanding of the physio-chemical environment and the ecological status of the water quality of the ecosystems, the assessment of the water quality will focus on the following aspects:

- Characterization of the physio-chemical environment of aquatic ecosystems
- Characterization of the ecological status of the waters
- Determining the level of chemical (heavy metals and pesticides) and microbiological pollution of aquatic ecosystems

For the realization of this study, two types of methodological approach will be explored. The first will consist of in situ physio-chemical characterization and bio-ecological characterization in the field. Additional laboratory analyses can be conducted to further assess chemical pollution level and microbiological analysis. Details of these methodologies are listed in Appendix I.

MOSQUITO LARVAL ABUNDANCE

As a secondary research priority, we propose mapping larval mosquito communities in relation to forest cover and quality and human settlements to understand vector-borne disease risks. This will support an understanding of how land-use change affects vector-borne diseases such as malaria, filariasis, and arboviruses. We will sample mosquito larvae from the water body nearest each village and by transect and taxonomic identification. The larvae samples will be analyzed for larval abundance. An additional option is to also assess the prevalence and intensity of water-related diseases, such as schistosomiasis, soil-helminths-transmitted and protozoa infections, in nearby human settlements through cross-sectional parasitological surveys using a door-to-door approach and entomological investigations.

ZOONOSES

To understand dynamic processes around viral zoonotic spillover, data collection is required across three areas: (1) host population dynamics, (2) exposure/contact between humans and reservoir hosts, and (3) probability of human infection given a contact. To identify and evaluate interventions to reduce viral zoonotic spillover, data would need to be collected across these areas, across both treatment and control sites. A longitudinal panel sample of the same individuals and wildlife would enable documenting and tracing the timing of exposure (and seroconversion[15]) events for zoonotic spillovers, as well as monitoring the long-term impacts of improved forest habitat on human physiology.

Assuming that a comprehensive set of data is collected, the following outcomes can be explored through an IE focused on measuring zoonosis spillover risk:

- Wildlife disease burden
- Human disease risk
- Zoonotic spillover risk[16]

Key data to collect to understand the mechanisms of viral zoonotic emergence are reservoir host, population distribution and viral load. Spatial and temporal variation in zoonotic risk factors makes longitudinal surveys across multiple sites essential (albeit logistically challenging and rare in practice). Fitting mechanistic models to empirical data on host and population distributions and viral loads allows testing different mechanisms (Gentles et al. 2020) and can improve forecasting of viral zoonotic risk in changing landscapes, as well as interventions such as land use planning to reduce spillover.

[15] Seroconversion is the transition from the point of viral infection to when antibodies of the virus become present in the blood.

[16] Quantifying zoonotic risk is a rapidly evolving field. Expert opinion, host trait, and viral trait data have been used to predict the zoonotic potential of viruses (Grange et al. 2021; Olival et al. 2017). Newly developed machine learning algorithms make quantitative predictions of zoonotic risk directly from viral genome sequences (mollentze_2021_plosbio).

RESERVOIR - HUMAN CONTACTS

Contact between reservoirs and humans can be estimated based on survey responses and movement data. Household surveys and data from line-transect walks can be used to record sightings and contacts with animal hosts. For enumerators performing line-transect walks, individuals can be recruited to wear GPS tracking devices to record movements and maintain activity diaries to identify duration and types of contacts, linked to recorded spatial locations. These transect walks would support data collection across biodiversity and zoonosis outcomes.

PROBABILITY OF HUMAN INFECTION GIVEN A CONTACT

Whole blood and serum samples from individuals are needed to understand variation in exposure to wildlife pathogens. Serology can be used to measure antibodies to past viral exposures (i.e., VirSCAN), and PCR and/or metagenomic sequencing can be used to measure active infections of focal pathogens.[17]

These data can be collection through household surveys, direct wildlife health sample collection, and direct human health sample collection.

HOUSEHOLD SURVEYS

Zoonotic risk in humans is not solely reliant on biological characteristics (i.e., hosts and virus abundance) – research must incorporate human behavior and movement to understand how infection risk changes in these landscapes. Household/individual level survey instruments enable the collection of mechanisms and risk factors, including food insecurity, poverty, hunting behaviors, and other activities that involve close contact between wildlife and humans.

Household and community survey information collected through the RESTORE IE's human/social data collection provides an opportunity to collect data on the individual factors that heighten the risk for viral zoonotic emergence, including human population density, cropland area, forest conversion, frequency of human interactions with wild animals, as well as cultural practices and behaviors, such as wild animal hunting and wild meat supply chains, particularly the trapping and transport of live animals.

Semi-structured household questionnaires can be used to identify protective measures that individuals employ to reduce contact with potentially infectious material (i.e., wearing waterproof boots, storing food apart from sleeping arrangements). Cultural practices and individual behaviors, including protective

[17] Technological developments and decreasing sequencing costs now enable quantitative characterization of entire viral communities within individual hosts without prior knowledge of species present. This approach, known as metagenomics, characterizes all genetic material in a sample and has led to the discovery of thousands of new virus species across many ecosystems and host species. What is particularly exciting is that the sequences generated by metagenomics can be repurposed to predict human infectivity (Mollentze and Streicker 2020). These two advancements —decreases in sequencing costs and computational methods to estimate human infection risk— provide an opportunity to survey and estimate human risk from entire communities of hosts. These approaches are still costly, but sample design, including pooling multiple individuals, can help maximize information and detect the effects of interventions.

measures and movement, can be included in mechanistic models to understand factors affecting observed exposure signatures and active infections.

WILDLIFE HEALTH

Measuring wildlife health through biological samples and measurements from wild mammals is critical to understanding zoonosis spillover risk. All captured animals should be tagged to enable longitudinal tracking of recaptured individuals.

Ideally, given the RESTORE study context, the evaluation will include primates, bats, rodents, and domestic animals. However, this scope of data collection might not be feasible given budget constraints. Specifically, best practice for integrated zoonotic research (e.g., HIH Madagascar study) lays out a sampling plan that involves wildlife health sampling two times per year over a ten-year period. At the species level, at each time point, a minimum of 30 individuals should be sampled across five focal primate species, five focal bat species, etc. for each focal species. At present, in the likely case that we need to restrict the number of focal animals, based on the information reviewed from our local consultant, the FA team will consider focusing design considerations on primates, rodents, and bats.

For wildlife health, the following data sources and measurements are recommended, in line with the HIH IE that is underway in Madagascar:

- Blood serum for serology
- Whole blood to test for RNA viruses of pandemic potential
- Hair samples for isotope analysis to determine host health and diet
- Wing punches (bats only) to determine age from methylome sequencing
- Fecal samples to test for intestinal RNA virus shedding (coronaviruses) and microbiome
- Urine samples for RNA virus shedding (paramyxoviruses, hantaviruses)
- Saliva samples for RNA virus shedding (filoviruses)
- Ectoparasite samples as viral and bacterial vectors, and as markers of host health
- Wildlife veterinary health exams
    - These health exams will be conducted with indicator/sentinel species. The health exams will include a physical exam, body condition score, complete blood count, fecal exam, and ecto- and endoparasite burden analysis (Wilkinson and South 2002).

HUMAN HEALTH

In addition to wildlife health, human health and exposure must be assessed for a comprehensive IE of interventions to mitigate zoonotic spillover. This would enable for testing whether forest restoration changed the frequency and diversity of wildlife-associated pathogens detected in the human population.

In addition to human health surveys and administrative health data (where available), the most rigorous data sources for assessing human health include blood samples from rapid diagnostic tests or dried blood spots for use in genetic research of malaria transmission.

- Health surveys (longitudinal), with basic physical exam

- Human biological sampling
- Records of patient visits where available

For the RESTORE IE, we recommend implementing a health module as part of the household survey. If possible, this would be paired with standard biological samples (e.g., blood, urine, fingernails). The human samples would need to undergo assay for target pathogens of zoonotic interest at laboratories.[18] This would include serology and unbiased RNA metagenomic sequencing. Best practice recommends human health sampling twice per year.

VII. Statistical Power

This section includes an analysis of statistical power related to outcomes such as well-being, livelihoods, behavioral change, health, and governance, followed by a discussion of similar considerations for remote sensing-based forest related outcomes and biodiversity/wildlife outcomes.

HOUSEHOLD AND GROUP-LEVEL SOCIAL OUTCOMES

The RESTORE Activity is a cluster-based intervention, whereby a group (cluster) of households comprising a community will be exposed to one, or a combination, of the SAs. The package of activities is expected to benefit households[19] and the community. For clustered interventions such as the RESTORE Activity, the total number of clusters in the IE sample is the most important factor for determining the statistical power of the IE design. Statistical power helps control the likelihood of a false negative—in other words, concluding that the program did not have an impact when in reality it did. Increases in power (or more confidence in measuring a statistically significant difference between treatment and comparison areas when, in fact, a difference exists) require a larger sample size and result in a smaller minimum detectable effect size (MDES), all else equal.

Generally, IEs of cluster-based interventions can be under-powered when there are a limited number of available treatment clusters (as larger sample sizes will result in larger statistical power) and when there is more heterogeneity (i.e., variation) across clusters, which is expected for the RESTORE Activity given the very large geographical area covered by the program. That said, at this time, the FA team does not anticipate that the total number of on-farm planting intervention communities will be a limiting factor. The total number of communities expected to be influenced by the off-farm planting portion of the intervention will be determined in the scoping trip. However, the FA team expects substantial heterogeneity between countries, as the tenure system and the tenure arm of the RESTORE intervention are substantially different in each country. Thus, we decided to treat the intervention in each country as separate interventions.

[18] These costs can be in the several million range and would need to be covered through a partnership with the NIH or another organization.
[19] It should be noted that different implementation activities might affect some or all households within a program community, and that not all households in a program community might directly benefit from activities.

The FA team has conducted preliminary power calculations to determine the MDES—the smallest program impact that the evaluation can confidently detect through statistical analysis—for different sample sizes and evaluation design options.[20] It is important to consider the MDES and whether it is in line with policy and program expectations. For example, if the evaluation is powered only to detect impacts larger than realistically expected given the planned activities, it is more likely that the results will be statistically insignificant. Therefore, if the MDES is larger than expected program impacts, other designs or evaluation approaches should be considered.

The FA team conducted power calculations for measuring outcomes at both the household level and cluster/community level. We calculated MDES for both binary outcomes and continuous outcomes. Illustrative binary household-level outcomes include land rights obtained, perception of tenure security, agroforestry practice adopted, below poverty line, food insecurity experience, engagement with high-risk wildmeat consumption and unsustainable use of ecosystem resources, women, and youth access to credit, and high achieve in empowerment index. For binary outcomes, the MDES are presented in terms of percentage point difference between control and treatment arms. The MDES of binary outcomes is also determined by the proportion of households with such a characteristic at baseline, with those indicators with lowest and highest baseline levels to have a higher MDES, and those with around a baseline level of 0.5 being the hardest to detect change holding all else constant. We calculated MDES for outcomes where the baseline proportion is expected to be zero, with no household expected to have the characteristic at baseline; as well as those where baseline proportion is expected to be 0.2, with some households having the characteristic at baseline.[21] For continuous outcomes (i.e., cocoa production and yield, income from sustainable cocoa farming), we presented the MDES in standard deviation form.

Figures 7a to c below illustrate the relationship between the MDES and the number of clusters (per treatment arm per country) for a variety of different sampling scenarios for **household level outcomes**, varying the number of households surveyed per community (n) from 12, 15, 30 to 45, and varying the intra-cluster correlation (rho)[22] from 0.1 to 0.3. Table 5 illustrates the MDES in table form for cluster numbers of 50, 75, and 100, with cluster sizes of 12 and 30, with rho of 0.2. To help us determine the feasible approaches to evaluate the tenure component and alternative livelihood component of RESTORE, we also calculated the MDES for a cluster number of 5 (for the 5 communities receiving the tenure intervention), as well as a cluster number of 20 and cluster size of 20, for the estimated 400 of recipients of the alternative livelihood VSLA assistance, assuming that they will be rolled out in only a subset of the program communities.

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[20] The FA team conducted power calculations using Stata's clustersampsi command. Parameters: power = 0.80; alpha = 0.05. The FA team also accounted for 15 percent attrition, and 25 percent correlation with baseline values or other predicative covariates and the outcome.

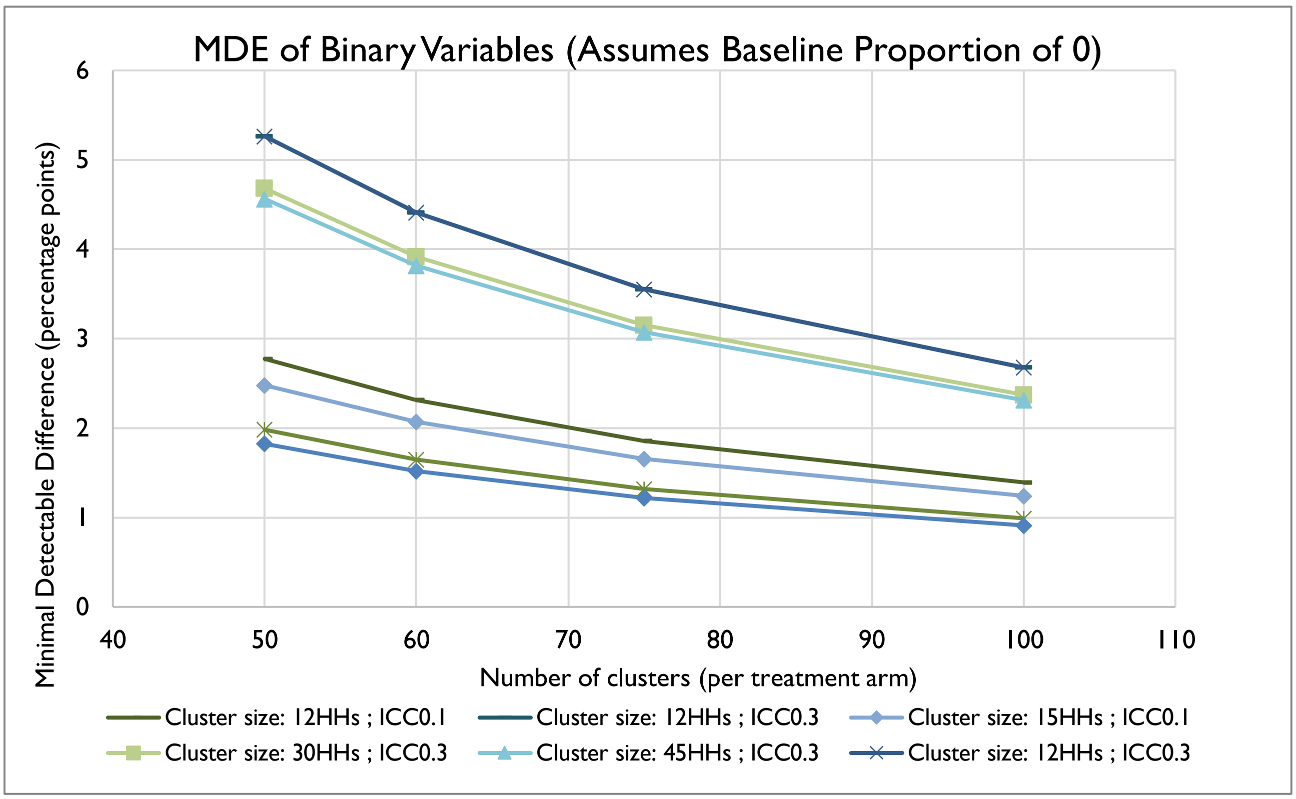
[21] In other words, a baseline level of 0.5 indicates a scenario where 50 percent of households at baseline have the characteristic. A baseline level of 0.2 indicates a scenario where 20 percent of households at baseline have the characteristic.

[22] The intra-cluster correlation coefficient measures the relatedness/similarity of responses within a cluster. The higher the coefficient, the more similar households are within a community on key characteristics or outcomes and the higher the required sample size.

It should be noted that increasing the number of households in the IE sample (i.e., by increasing the number of households surveyed per community) has only a minimal effect on MDES, particularly increasing above 15 household per community. The benefit of increasing the sample size of households within a community above this level would be in ability to measure impacts for different types of households or individuals (subgroups) rather than increasing overall power.

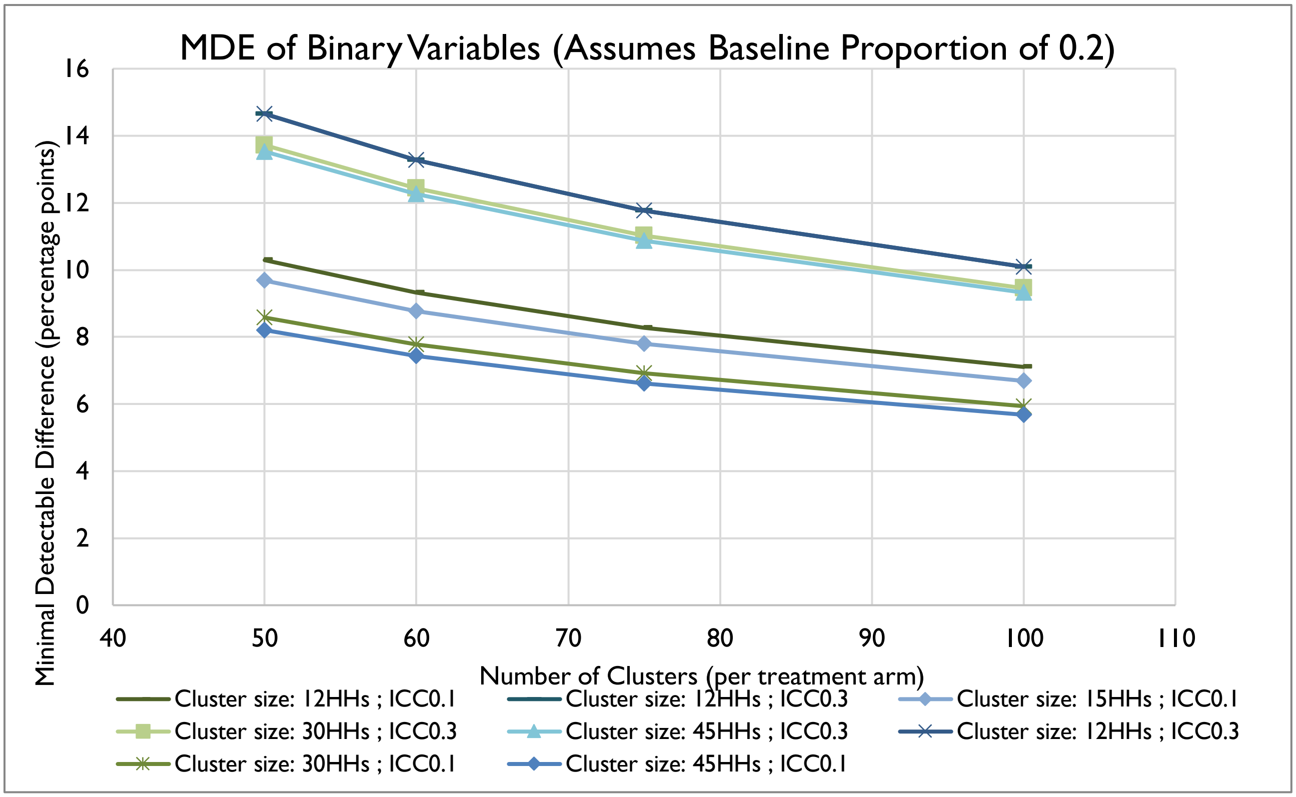
Even with smaller sample sizes 12 households per community, with 50 to 75 communities per treatment arm, the IE would be powered to detect a small effect size of binary outcome (3 to 4 percentage points) with baseline proportion of zero; a moderate effect size of binary outcome (10 to 12 percentage points) with baseline proportion of 0.2; and a moderate effect sizes of continuous variables of between 0.24 and 0.39 standard deviations.[23] Raising the cluster numbers to 100 communities per treatment arm (600 to 900 households), the IE would only be slightly more powered, to detect smaller effect sizes of 2 and 9 percentage point differences for binary variables, and continuous variable of lower than 0.20 standard deviations.

(a)



[23] Generally, MDES less than or equal to 0.20 standard deviations are considered small, between 0.20 and 0.50 moderate, and greater are considered large.

(b)



(c)

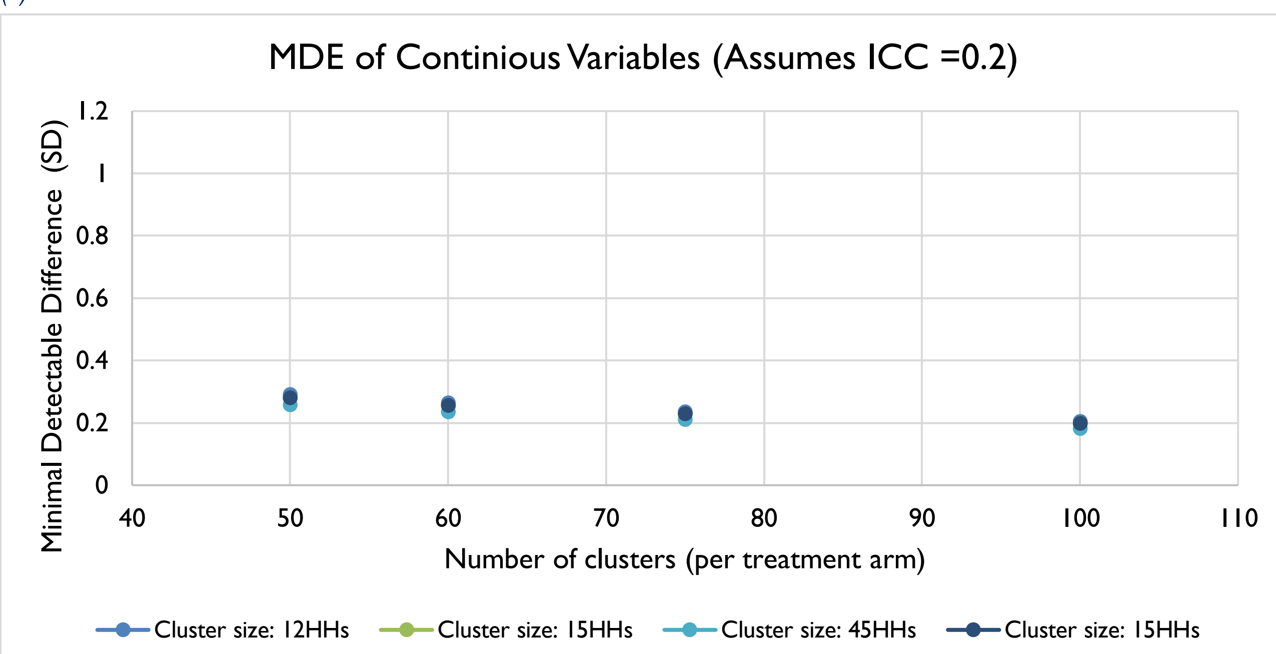
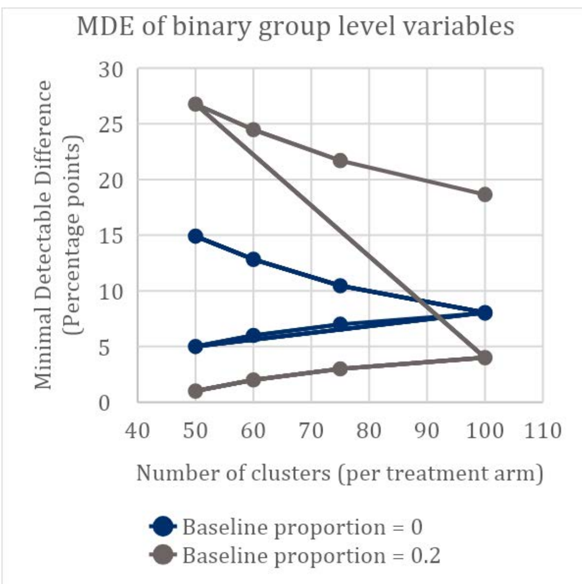


***Figure 7**. Relationship between MDES and number of clusters – household level outcomes. (a) presents the MDES of binary variables assuming a baseline proportion of 0; (b) presents the MDES of binary variables assuming a baseline proportion of 0.2; (c) presents the MDES of continuous variables*

Figure 8 below illustrates the relationship between MDES and the number of clusters for **community level outcomes**. Overall, the IE will be powered to detect only larger program impacts for the group level outcomes than it will for the household level outcomes. This is because for group level outcomes, there is only one observation or treated unit for each given period. Even with a total sample size of 100 communities, the MDES for group level outcomes is 8 to 20 percentage points or 0.40 standard deviations, which is a moderate effect size. Smaller sample sizes of 50 to 75 communities per arm have MDES estimated between 10 to 27 percentage points or 0.5 to 0.6, which are large. In other words, the RESTORE Activity would need to have large impacts on community level outcomes like governance or natural resource management-related outcomes for the IE to distinguish real impacts from zero, particularly for continuous variables. If the RESTORE Activity results in smaller changes in these group level outcomes, the IE will likely be unable to detect these impacts.

(a) *(b)*



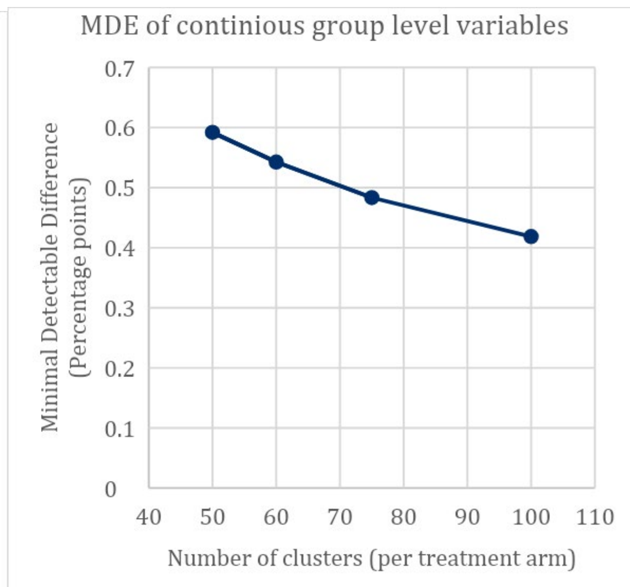


Figure 8. *Relationship between MDES and number of clusters – group level outcomes. (a) presents the MDES of binary outcomes and (b) presents the MDES of continuous outcomes*

Table 5 lists two scenarios for evaluating the five communities where the tenure intervention will be implemented as part of RESTORE as an IE, varying the number of HHs surveyed in each community. The result shows that even with a higher cluster size of 30 instead of 12, the MDES for household-level outcomes is unrealistically large at 29.80 to 41.09 percentage points for binary outcomes and 0.92 standard deviations for continuous outcomes. For this reason, we do not recommend an IE approach to evaluating the tenure component.

For the VSLA component, we likewise assessed two scenarios, one where the intervention recipients of 400 individuals are spread out across 20 communities, and the extreme scenario where they are each in separate communities maximizing the number of clusters. The actual participant recruitment is yet to be determined by the IP. The result shows that a realistic design of 20 clusters with a cluster size of 20 individuals each can detect a moderate effect size of 8.73 to 19.54 percentage points for binary outcomes, and 0.44 standard deviations for continuous outcomes.

The FA team looks forward to discussions with USAID, RA and ofi regarding whether these effect sizes are consistent with expectations for RESTORE Activity impacts. If MDES are much larger than could be realistically expected to achieve based on programming, the potential for useful learning through an IE is at greater risk, as smaller impacts would be indistinguishable from zero.

DESIGN AND ANALYSIS CONSIDERATIONS FOR BIOPHYSICAL OUTCOMES

As detailed above, **tree cover loss/gain** will be a primary outcome. Satellite-based images are analyzed as raster data, which are comprised of pixels. For analysis, each pixel is a unit of observation. Pixel size will vary based on the satellite being used (e.g., Moderate Resolution Imaging Spectroradiometer [MODIS] has 250m resolution per pixel, whereas Hansen has 30m resolution). While the off-farm restoration areas are yet to be determined, based on the 5,000 hectares of forested land under restoration program target, and possible comparison sites, the FA team is confident that they will be sufficiently powered to detect realistic changes in forest cover and other remote sensing-based outcomes between treatment and control sites. Details of treatment and control site size and location will be determined during the scoping trip.

In addition, the FA team considered Kays et al. (2020) evaluation of **camera trap** study design parameters to inform the proposed number of sites, duration, and season of sampling to maximize precision of estimates of species richness, occupancy, and detection rate for mammals, including species relevant for zoonosis disease transmission.[24] Their overall recommendation is that each sampling bout should run for three to five weeks across 40-60 sites per array, at a minimum. However, the precision of species-level estimates of occupancy was highly sensitive to occupancy level, with more than 150 camera sites or longer time intervals, likely needed for rare species. The study also recommends that comparisons of detection rates be model-based and include environmental covariates (e.g., vegetation type) to help account for variation in detection, and that comparisons across study areas or times must account for seasonality, which could have strong impacts on mammal communities in both tropical and temperate sites. Similar to details of the tree cover design, much is still unknown and to be determined at the scoping trip, regarding the location and size of off-farm sites, distance to human settlements, distance to other ecological corridors, and species occupancy level to form a detailed design.

[24] Kays et al., "An empirical evaluation of camera trap study design: How many, how long and when?" *Methods in Ecology and Evolution* 11, no. 6 (2020): 700-713, https://doi.org/10.1111/2041-210X.13370.

***Table 5**. MDES for Different Sample Sizes, Matched Comparison Group DID Design*

Minimum Detectable Effect SZEs for Different Sample Sizes	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Tenure (min. HHs per cluster)	Tenure (max. HHs per cluster)	VSLA (Large cluster sizes)	VSLA (Small cluster sizes)
Number of communities per country												
Number of treatment communities per country	50	50	60	60	75	75	100	100	5	5	20	100
Number of comparison communities per country	50	50	60	60	75	75	100	100	5	5	20	100
Number of communities per country	100	100	120	120	150	150	200	200	10	10	40	200
Number of HHs per community	12	30	12	30	12	30	12	30	12	30	20	4
Total HH sample size*	1200	3000	1440	3600	1800	4500	2400	6000	120	300	800	800
Minimum Detectable Effect Sizes												
MDE for household level binary outcomes, baseline proportion=0 (percentage points)	4.04	3.35	3.37	2.80	2.71	2.24	2.04	1.69	34.00	29.80	8.73	3.35
MDE for household level binary outcomes, baseline proportion=0.2 (percentage points)	12.64	11.41	11.45	10.34	10.16	9.17	8.71	7.87	44.72	41.09	19.54	11.41
MDE for household level continuous outcomes (sd)	0.29	0.26	0.26	0.24	0.24	0.21	0.20	0.19	1.01	0.92	0.44	0.26
MDE for community level binary outcomes, baseline proportion=0 (percentage points)	14.91	14.91	12.83	12.83	10.46	10.46	8.05	8.05	71.04	71.04	NA	NA
MDE for community level binary outcomes, baseline proportion=0.2 (percentage points)	26.77	26.77	24.47	24.47	21.70	21.70	18.65	18.65	73.54	73.54	NA	NA
MDE for community level continuous outcomes (sd)	0.59	0.59	0.54	0.54	0.48	0.48	0.42	0.42	2.21	2.21	NA	NA

Notes:
a. MDES = minimum detectable effect size (calculated in units of standard deviation from the mean)
b. Calculations assumed a confidence level of 95 percent, one-tailed tests for binary outcomes and two-tailed tests for continuous outcomes, 80 percent power, 15 percent non-response rate, 25 percent correlation with baseline values or other predicative covariates and the outcome, and 0.2 intra-cluster correlation coefficient.
† The number of households surveyed for the evaluation sample, not the total number of anticipated beneficiaries.
*The is total sample size for on-farm portion. If including off-farm IE, if assuming no on-farm and off-farm site overlap, the total sample size would be twice as much

VIII. Illustrative Cost by Evaluation Design

Table 6 below provides illustrative baseline cost estimates to conduct the scoping trip, finalize the evaluation design, conduct data collection, and analyze and report on findings for different scenarios with three options of "add-ons" for the zoonosis and arbovirus components. We present budget options for three rounds of data collection (a baseline, an endline, and a follow-up) and two rounds (baseline and endline only) in Appendix C. We also list the cost of the scoping and design phase only. Details of the scoping trip proposal and budget breakdown are included in Appendix D.[25]

The first two scenarios are conservative and optimistic budgets for ideal evaluation designs. Scenario 1 makes a conservative estimate that there is not overlap between on- and off-farm treatment communities, thus requiring completely separate social data collection (Design B in Section V). Scenario 2 makes an optimistic assumption that there are large overlaps between on- and off-farm treatment communities, thus, the sampled communities for the two components of the evaluation can be the same (Design A in Section V).

Scenario 3 to 5 provide cost reduction options mentioned in Section V. Scenario 3 reduces the on-farm community sample from 75 per country-treatment group to 50 per country-treatment group, thus reducing the cost of social data collection. Scenario 4 reduces the scope of the evaluation to CDI. Scenario 5 reduces the scope of the evaluation to the off-farm IE only.

Compared to a typical program evaluation, the proposed evaluation is costly due to several factors:

- We recommend viewing the bundles of RESTORE "treatment" in Ghana and CDI as separate treatments as the two country contexts significantly differ in terms of land and tree tenure and extent of LMB maturity. This doubles the number of communities needed in the sample to achieve proper power for statistical analysis.
- RESTORE activities are targeting towards two types of conservation behavior- one is on-farm tree planting and one is off-farm tree planting. Not only does the implementation for each type of planting fall on different programming schedules, the evaluation of these two components also contribute to different learning questions and body of knowledge. The participants and planting area of these two groups of activities are also likely to differ (the extent of overlap is to be determined at scoping trip). Thus, the evaluation of RESTORE as a whole is in essence two evaluation designs combined, with both components having social indicators to track household and community surveys. This again doubles the number of communities needed in the sample to achieve proper power for statistical analysis.

[25] In the September ecological scoping trip, the ET confirmed that the off-farm planting location will be in the same communities as the on-farm program locations. Thus, the scenarios (scenarios 1, 3, 4, 6, 7, 8) that assume no overlap between these program components are no longer relevant.

- The IPs do not currently undertake any biophysical data collection. Thus, the evaluation team will have to undertake all the biophysical data collection in both treatment and comparison areas, including forest plots, soil sampling, camera traps and zoonoses monitoring. These data collection methods involve field teams with specialized knowledge and tools, and for certain indicators lab analysis, making it a very costly undertaking. The cost of biophysical data collection is a common challenge in conservation program evaluations, as described in the "State of the Evidence" section (Section IV). The zoonosis component is especially costly, though part of the objective of the scoping to is to understand the possibility of partnering with existing zoonoses monitoring initiatives on RESTORE landscapes.
- Operating in two countries means that the contract management and data collection team management costs are slightly higher.

Scenario 6 to 9 make further trade-offs to arrive at more conservative budgets. Scenario 6 eliminates the on-farm comparison group data collection. As discussed in the design options Section V, an option for comparison group for the agroforestry component is non-RESTORE ofi cooperatives, utilizing significant agronomy-related monitoring data already collected by ofi. To assess the feasibility of this option, the FA team needs to have further discussion with the IP during the scoping trip to understand the difference between the RESTORE model and other ofi models.

Scenario 7 further scales down the budget by reducing the number of communities sample for the off-farm component from 75 to 50. The power analysis shows that a cluster number of 50 still allows the research design to detect moderate level effect sizes. The tradeoff is a decrease in statistical power to make sub-sample analysis at the community level, if there are significant differences between clusters, for example across landscapes or cooperatives. Scenario 8 scales down scenario 7 to CDI only, and Scenario 9 takes Scenario 8 and assumes large overlaps between on-farm and on-farm areas to combine social data collection.

For all scenarios, the budgets without add-ons include the following data collection activities:

- On-farm communities data collection:
  - Community listing (to ground truth location/existence and demarcation of villages)
  - Household surveys
  - Women's surveys
  - Focus group discussions
  - Key informant interviews
  - Community leader surveys
- Off-farm communities data collection:
  - Community listing (to ground truth location/existence and demarcation of villages)
  - Household surveys
  - Community leader surveys
- Off-farm ecological assessment:
  - Remote sensing forest cover analysis
  - Once-per-round data collection for forest plot for forest carbon (field), soil carbon (field + lab)

- Twice-per-round camera traps and transect walks for biodiversity
- Twice-per-round wildlife zoonosis spill-over risk tracking for primate and bat species (field + lab)[26]

We also listed **additional elements** for the zoonotic component, to include an option to add human blood sample, and an additional option to add RNA sequencing. We also include an add-on option for arbovirus tracking, that includes once-per-round water quality and mosquito larval abundance analysis. All data collection costs are illustrative only and must be refined during IE design phase through a competitive bidding process to data firms.

[26] We assume combined field work for biodiversity assessment and zoonotic sampling for cost savings.

IX. Summary

Overall, the FA team identified several benefits of a RESTORE evaluation for USAID learning:

1. There are no published IE of forest restoration projects. RESTORE provides an opportunity to study conservation outcomes – at minimum through remotely sensed data, but (budget pending) also biodiversity outcomes and conservation behaviors through household data collection.
2. There are no rigorous PEs/IEs of alternative livelihood programs.
3. There are no rigorous PEs looking at long term results and sustainability for any of the RESTORE activities.
4. IEs offer a way to quantify and evaluate the effectiveness of programs or policies aimed to mitigate the drivers of zoonotic spillover. However, at present, no IEs have been completed on the effectiveness of interventions to mitigate the risk of zoonotic spillover.

As such, the FA team recommends a rigorous PE for the on-farm interventions of the RESTORE program, including tenure strengthening and tree-planting support (on-farm part of SA1), establishing and strengthening participatory LMBs (SA2) and regenerative agriculture/ cocoa agroforestry assistance (SA3). The alternative livelihood VSLA component (SA4) may be amendable for an IE design pending more information on recipient selection. The FA team recommend an IE design for the off-farm intervention component (off-farm part of SA1) to evaluate the impact of such conservation program on flora and fauna biodiversity, risk of zoonotic spill-over and social well-being of nearby communities.

The budget of this ideal research design is more costly compared to a typical program evaluation due to several factors: 1) The different contexts of Ghana and CDI; 2) The separate on-farm and off-farm planting components of RESTORE; 3) The cost of undertaking biophysical data collection across forest ecology, biodiversity and zoonoses indicators in both treatment and comparison areas; and 4) The slightly higher management costs of operating in two separate countries. In the illustrative budget descriptions, the FA team considers several ways to reduce the budget without losing the statistical power and learning value of the evaluation. We look forward to continuing to discuss with USAID and IPs to develop the evaluation design and scope.

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Appendix A: Illustrative List of Evaluation Indicators

Table 7. *Illustrative List of Evaluation Indicators*

Site	Outcome Type	Outcomes	Indicators	Data collection instrument
On-Farm, Off-Farm	Food Security and Nutrition	Increased dietary diversity and dietary intake	Percent of women of reproductive age consuming a MDD-W; Percent of children 6-23 months receiving a minimum acceptable diet	Household survey; women's survey
		Improved individual or household food security	Percent of households experiencing moderate and severe food insecurity, based on the Food Insecurity Experience Scale	Household survey; women's survey
On-Farm	Tenure Security	Perceived Tenure Security	Measures of perceived tenure security across potential drivers of tenure insecurity	Household survey; women's survey; Focus Group Discussions (FGDs)
		Land Rights	Measures of bundle of land rights	Household survey; women's survey
		Land Conflict	Incidence of conflict; perceptions of future conflict	Household survey; women's survey; FGDs
On-Farm, Off-Farm	Governance	Improved business capacity of LMBs	Business and admin capabilities	KIIs, admin data (if available)
		Improved collective action	Evidence of changes in collective action	Household survey; women's survey; FGDs; KIIs
		Improved governance/NRM management capacity of LMBs	Governance and management capacity	Household survey; women's survey; FGDs; KIIs
		Improved landscape management	Development and sustainability of Landscape Action Plans (LAPs)	Household survey; women's survey; FGDs; KIIs
		Improved participatory landscape governance	Improved community voice and decision-making; Average score across Site-Level Assessment of Governance and Equity outcome areas	KIIs, FGDs, admin data (if available)

On-Farm, Off-Farm	Health	Improved household drinking water (Incidence of water-borne illness)	Percent of children under five with diarrhea in the past two weeks; Percent of children under five with diarrhea in the past two weeks treated with oral rehydration solution	Household survey
			Percent of household members with diarrhea in the past three months	Household survey
		Vector-borne disease	Malaria incidence (adults and children)	Household survey; admin records (if available)
			Wildlife associated pathogens	Human biological sampling; blood spot samples; admin records
On-Farm, Off-Farm	Conservation Knowledge, Attitudes, and Practices	Improved knowledge and attitudes towards conservation and natural resource management	Average score measuring the perceived importance of protecting nature and the environment.	Household survey; women's survey
			Improved community understanding of ecosystem benefits	Household survey; FGD
			Understanding of environmental benefits of shade trees and CSA	Household survey; FGD
		Climate resilience	Perceptions of climate vulnerability	Household survey
On-Farm	Investment and Productivity	Increased agricultural productivity	Average cocoa production and yields	Household survey; At Source, OFIS,
			Non-cocoa yield	Household survey
			Cocoa agricultural income	
			Non-cocoa agricultural income	Household survey
		Increased use of sustainable/regenerative practices	Percent of households using HEARTH promoted CSA technologies/practices; Number of hectares under improved management practices or technologies	Household survey
		increased adoption of climate resilient cocoa agroforestry systems	Good agricultural practices	Household survey
			Percent of households adopting climate resilient cocoa agroforestry systems	Household survey; At Source, OFIS,
On-Farm, Off-Farm	Socio-Economic Well-Being	Increased socio-economic status	Percent of households below the comparative threshold for the poorest quintile of the Asset-Based Comparative Wealth Index	Household survey
		Expenditures	Change in per capita household consumption/expenditures in key areas such as health, education, etc.	Household survey

		Increased farmer income	Income	Household survey
		Increased diversification of farmer incomes	Diversified sources of revenue	Household survey
		Increased prevalence of start-up enterprises	Increased incomes for SME producers	Household survey
On-farm	Women's Empowerment	Increased women's empowerment	Percent of women achieving high empowerment on the SWPER	women's survey
On-Farm, Off-Farm	Forest Outcomes	Reduced land clearing	Percent of households who engaged in unsustainable use of ecosystem resources in the past year; Percent of households that cleared land for cultivation in the past year	Household survey; satellite imagery
		Forest condition	Tree planting (by species and purpose-shade, timber, additional tree crop)	Household survey; satellite imagery; forest plot samples
			Forest loss/deforestation rates	Satellite imagery; forest plot samples
			Forest degradation	Satellite imagery; forest plot samples
On-Farm, Off-Farm	Biodiversity	Habitat improvements	Bio-corridor restoration	Satellite imagery; forest plot samples
			Diversified habitat structure and composition	Forest plot sampling
		Species richness	Number of species within an area	Camera traps; direct observation through transect walks
		Species abundance	Relative abundance of species within an area; Change in presence/absence of target species(s) across target area over a set time interval	Camera traps; direct observation through transect walks
On-Farm, Off-Farm	Zoonosis Spillover Risk	Human Health (see above)		
		Biodiversity and Conservation (see above)		
		Wildlife Health	Diet, health, virus shedding	Blood serum, hair samples, fecal samples, urine samples, saliva samples, ectoparasite samples, wildlife vet health exams
			Age	Wing punches for bats
On-Farm, Off-Farm	Climate change mitigation	Reduced emissions	Carbon sequestration and reduced GHG emissions	Satellite imagery; forest plot samples; soil carbon samples

Appendix B: Simplified Year 1 Workplan

***Table 8**. Simplified Year 1 Workplan*

Strategic Approach	Activities	Region	Earliest Start Date
SA 1: Improve tree and/or land tenure processes and strengthen incentives for tree growing and conservation to restore tree cover and protect forest	**1.1:** *Farmers are aware of and have access to incentive mechanisms for tree planting* through: educational programs to communicate the benefits of conserving and planting trees, mapping and taking inventory of trees, designing, and implementing participatory plans for tree planting, and the creation of native tree nurseries.	Côte d'Ivoire Ghana	Oct-22
	1.2: *Farmers apply best agroforestry practices* by: delineating community boundaries, properly mapping delineated villages and registering them with the government, participating in REDD+ Broker, establishing agroforestry and restoration systems, facilitating tree growing on cocoa farms, conducting analysis to understand the technology to benefit from carbon removal, and developing an accounting system for climate benefits.	Côte d'Ivoire	Aug-22
	1.3: *Development of a time efficient system for tree tenure* by: brokering agreements with Resource Management Support Center, providing trainings for Forestry Commission staff and Forest Services Division, setting up a digitalized platform for tree registration, select and train community enumerators to collect data on farm trees (Sui River only).	Ghana	Aug-22
	1.4: *Development of a Landscape Action Plan* by: identifying areas of importance for community members and biodiversity, facilitating agreements with community stakeholders to establish protected areas, mobilize community members for restoration efforts, supporting maintenance of native trees, and securing external funding to support tree growing and restoration.	Côte d'Ivoire (Bossematie) Ghana (Sui River)	Aug-22

Strategic Approach	Activities	Region	Earliest Start Date
SA 2: Establish and strengthen the business and governance capacity of LMBs and improve the conservation and natural resource management support that they provide to farmers	**2.1**: *Improvement of business/governance capacity of LMBs for conservation and resource management* by: increasing stakeholder awareness of community-based conservation, mapping and analyzing landscape boundaries and conditions, reaching formal agreements for landscape management with local authorities, increasing local capacity for inclusive landscape governance.	Côte d'Ivoire Ghana	Aug-22
	2.2: *Inclusive platforms of landscape actors are established* by: guiding existing and new LMBs to become socially inclusive, encouraging stakeholder endorsement of sustainable landscape management plans and supporting implementation – including financial planning.	Ghana (Sui River)	Oct-22
	2.3: *Adaptive management and monitoring are established to inform appropriate investment in the landscape* by: guiding LMBs in setting indicators and data collection plans, encouraging adaptive management and planning based on performance.	Ghana (Sui River)	Oct-22
SA 3: Increase use of climate-smart, more productive, regenerative, and sustainable cocoa production by improving farmers' capacities, knowledge, and resources"	**3.1:** *Farmers have improved skills and knowledge to practice climate-smart and sustainable cocoa production* by: creating, implementing, and supporting a training curriculum – including identification and training of diverse trainers - based on climate zones across landscapes.	Côte d'Ivoire Ghana	Aug-22
	3.2: *Farmers implement climate smart techniques for healthy cocoa and other environmental and economic benefits* by: guiding farmers as they apply practices, establishment of Youth Sustainability Groups, sharing of best practices through media channels, identifying financial mechanisms for climate smart farming investments.	Côte d'Ivoire Ghana	Nov-22
	3.3: *Increased profitability of cocoa farmers implementing climate smart actions* by: collecting and recording data on cocoa yields, prices, and profitability then presenting the information in a digestible format for a diverse audience.	Côte d'Ivoire Ghana	Oct-22
SA 4: Promote and strengthen forest-friendly livelihood diversification through women- and youth-inclusive approaches that improve skills and access to fundings, inputs, and markets"	**4.1:** *Establishing access to finance, credit, training, and inputs to diversify farms* by: selecting communities in each landscape viable for VSLAs can be established/supported, as well as assessing schemes to finance and support micro and small enterprises.	Côte d'Ivoire Ghana	Oct-22
	4.2: *More people (especially women and youth) pursue forest-friendly entrepreneurial opportunities* by: partnering with enterprise clinics catering to women- and youth-led enterprises as well as facilitating discussions in LMB meetings to generate ideas for forest-friendly and environment-enhancing livelihood schemes.	Côte d'Ivoire Ghana	Oct-22

Appendix C: Detailed Illustrative Budget

Table 9. *Detailed Illustrative Budget*

Budget Estimate by Design Option	(1) Ideal IE design, no overlap (conservative estimate)	(2) Ideal IE design, large overlap	(3) Reduced on-farm sample, no overlap	(4) CDI only	(5) Off-farm only	(6) No on-farm comparison	(7) No on-farm comparison; Reduced off-farm sample	(8) CDI only; No on-farm comparison; Reduced off-farm sample	(9) CDI only; No on-farm comparison; Reduced off-farm sample; large overlap	Add-on: Zoonoses human	Add-on: Zoonoses RNA sequencing	Add-on: Arbovirus
Evaluation Parameters												
On-farm PE	Yes	Yes	Yes, reduced sample to 50	Yes	No	Yes, no comparison group	Yes, no comparison group	Yes, no comparison group	Yes, no comparison group			
Off-farm IE	Yes	Yes	Yes	Yes	Yes	Yes	Yes, reduced sample to 50	Yes, reduced sample to 50	Yes, reduced sample to 50	Yes	Yes	Yes
On/Off farm overlap assumption	No overlap	Large overlap	No overlap	No overlap	N/A	No overlap	No overlap	No overlap	Large overlap			
Countries	CDI + Ghana	CDI + Ghana	CDI + Ghana	CDI only	CDI + Ghana	CDI + Ghana	CDI + Ghana	CDI only	CDI only	CDI + Ghana	CDI + Ghana	CDI + Ghana
Baseline budget only												
Labor, Consultant, Travel, Other Direct Costs, G&A[a]	$349,973	$349,973	$349,973	$290,433	$264,702	$334,224	$334,224	$288,346	$288,346	$28,837	$28,837	$0
On-farm social outcome data collection	$450,421	$450,421	$375,000	$240,683	$0	$256,299	$256,299	$159,238	$159,238	$0	$0	$0
Off-farm social outcome data collection	$388,245	$194,123	$388,245	$194,123	$388,245	$388,245	$258,830	$129,415	$64,708	$0	$0	$0
Forest plot	$69,017	$69,017	$69,017	$51,763	$69,017	$69,017	$69,017	$51,763	$51,763	$0	$0	$0
Soil carbon	$70,158	$70,158	$70,158	$52,619	$70,158	$70,158	$70,158	$52,619	$52,619	$0	$0	$0
Camera Traps	$138,400	$138,400	$138,400	$103,800	$138,400	$138,400	$138,400	$103,800	$103,800	$0	$0	$0
Zoonosis	$381,164	$381,164	$381,164	$285,873	$381,164	$381,164	$381,164	$285,873	$285,873	$500,000	$100,000	$138,848

Total Estimated Budget (including escalation for plug + indirects)	**$2,158,108**	**$1,931,334**	**$2,070,000**	**$1,424,378**	**$1,532,312**	**$1,912,936**	**$1,761,753**	**$1,251,204**	**$1,006,346**	**$617,787**	**$150,507**	**$162,202**
Generalized Budget Parameters (3 rounds)												
Labor, Consultant, Travel, Other Direct Costs, G&A[a]	$824,620	$824,620	$824,620	$684,174	$627,670	$748,098	$748,098	$655,004	$655,004	$91,805	$91,805	$0
On-farm social outcome data collection	$1,433,962	$1,433,962	$1,124,999	$736,491	$0	$815,953	$815,953	$506,949	$506,949	$0	$0	$0
Off-farm social outcome data collection	$1,236,017	$618,008	$1,236,017	$594,015	$1,236,017	$1,236,017	$824,011	$412,006	$206,003	$0	$0	$0
Forest plot	$207,022	$207,022	$207,022	$155,267	$207,022	$207,022	$207,022	$155,267	$155,267	$0	$0	$0
Soil carbon	$216,223	$216,223	$216,223	$162,167	$216,223	$216,223	$216,223	$162,167	$162,167	$0	$0	$0
Camera Traps	$234,114	$234,114	$234,114	$175,586	$234,114	$234,114	$234,114	$175,586	$175,586	$0	$0	$0
Zoonosis	$1,073,831	$1,073,831	$1,073,831	$805,373	$1,073,831	$1,073,831	$1,073,831	$805,373	$805,373	$1,264,260	$318,360	$418,145
Total Estimated Budget (including escalation for plug + indirects)	**$6,104,767**	**$5,382,809**	**$5,743,837**	**$3,870,332**	**$4,199,536**	**$5,293,417**	**$4,812,112**	**$3,355,481**	**$2,666,349**	**$1,584,155**	**$479,155**	**$488,477**
Generalized Budget Parameters (2 rounds)												
Labor, Consultant, Travel, Other Direct Costs, G&A[a]	$580,384	$580,384	$580,384	$481,569	$440,900	$552,664	$552,664	$479,483	$479,483	$59,404	$59,404	$0
On-farm social outcome data collection	$927,868	$927,868	$749,999	$495,808	$0	$527,976	$527,976	$328,030	$328,030	$0	$0	$0
Off-farm social outcome data collection	$799,785	$399,892	$799,785	$399,892	$799,785	$799,785	$533,190	$266,595	$133,297	$0	$0	$0
Forest plot	$136,010	$136,010	$136,010	$102,007	$136,010	$136,010	$136,010	$102,007	$102,007	$0	$0	$0
Soil carbon	$362,288	$362,288	$362,288	$271,716	$362,288	$362,288	$362,288	$271,716	$271,716	$0	$0	$0
Camera Traps	$184,863	$184,863	$184,863	$138,648	$184,863	$184,863	$184,863	$138,648	$138,648	$0	$0	$0
Zoonosis	$717,410	$717,410	$717,410	$538,058	$717,410	$717,410	$717,410	$538,058	$538,058	$871,000	$206,000	$274,429

Total Estimated Budget (including escalation for plug + indirects)	**$4,332,395**	**$3,865,241**	**$4,124,609**	**$2,836,036**	**$3,085,515**	**$3,832,859**	**$3,521,422**	**$2,481,882**	**$1,991,238**	**$1,086,898**	**$310,045**	**$320,588**
Scoping trip + design	$82,135	$82,135	$82,135	$63,604	$60,018	$78,885	$78,885	$61,166	$61,166	$0	$0	$0

Notes:
a Conservative staffing estimates using INRM labor rates. All scenarios assume international travel for data collection and dissemination for each data collection round. Budgets are inclusive of: Team Lead; Senior zoonosis Expert; Senior forest ecologist; In-Country Coordinator; Evaluation Director, Manager/Specialist, and Assistant, U.S. university-based research assistants and data scientist; INRM Management support.
b Data collection costs are illustrative only and must be refined during IE design phase through a competitive bidding process to data firms. Assumes combined fieldwork for camera trap and zoonosis data collection
c Total estimated budget includes scoping trip and design costs

Appendix D: Scoping Trip Details and Budget Breakdown

The FA team proposes a scoping trip in late-March/ early-April to obtain key information for the evaluation design. The timing of the scoping trip is based on the IPs' workplan to have the off-farm restoration sites identified at the end of Q1 of 2023. As we determine that an IE is most feasible and valuable, in terms of filling existing knowledge gaps, for the off-farm planting portion of the intervention, knowing the location, size, and proximity to human settlements of the planting sites will be essential for the IE design. The FA team also hopes to understand better options for comparison communities for the on-farm intervention through talking to non-ofi cooperatives and farmer groups to understand potential differences between the ofi model and others. Specifically, the evaluation team hopes to continue discussion with USAID, RA, ofi and other IPs to clarify the following points:

- Detailed RESTORE implementation plans for each landscape
- On-farm intervention:
  - Differences between ofi models and non-ofi cooperatives and agroforestry models
  - Differences between cooperatives (ofi or non-ofi) and non-tradition and traditional farmers/ farmer groups not part of any cooperatives
  - AFOR intervention model, and workplan/progress in RESTORE villages
  - The extent of AFOR presence and progress in non-RESTORE villages on the target landscapes
- Off-farm intervention:
  - Synergies with existing Ecological monitoring and Zoonosis monitoring initiatives in the restoration landscapes
  - Existing governance rules/ management and enforcement arrangements at off-farm sites
  - Nearby habitation (RESTORE and non-RESTORE)'s forest-use behavior and forest interactions and dependencies
- The extent of on and off farm sites overlap and distance between on-farm and off-farm sites.

We are proposing a two-week trip (one week for the Team Lead and two weeks for the Research Manager) to visit both countries to answer the questions above. We are proposing provisionally two days in Abidjan, five days in Tai landscape, two days in eastern landscape and five days in Ghana, to undertake the following activities:

1. A long meeting with RA team
2. A long meeting with ofi team
3. Meeting with AFOR representative and AFOR local field office

4. Meeting with LMB and/or another cooperative coordinating organizations that works with non- ofi farmer cooperatives on cocoa agroforestry
5. Site visits to an ofi community, farmer cooperatives not in ofi, farmer group not in a cooperative, and traditional cocoa farmers
6. Meeting with management/enforcement org in the priority landscape for the off-farm restoration project (this might be Abidjan and local field office)
7. Meeting with any NGO/dev org or donor that is also working on off-farm restoration.
8. Site visit to potential off-farm restoration area – prioritizing one overlap area (overlap between on-farm and off-farm) and one where there might not be overlap, as well as the communities near/bordering the area

Table 10 below presents the budget breakdown.

Table 10. *Scoping Trip Budget Breakdown*

	Scoping trip (March/April 2023)		
	Units	Amount	Total
A. Planning			
1. SALARIES			
Evaluation Director	1.00	1,598.94	1598.94
INRM DCOP	0.00	1,442.72	0.00
Team Lead	1.00	1,078.53	1078.53
Forest ecologist	0.00	1,023.42	0.00
Zoonosis consultant	0.00	1,134.24	0.00
In-Country Coordinator	0.00	354.26	0.00
Evaluation Manager/Specialist	2.00	817.74	1635.48
Evaluation Assistant	3.00	404.47	1213.42
Upenn MA Student	0.00		
Upenn PhD Student	0.00		
Interpreter	0.00		
TOTAL ESTIMATED COST	**7.00**		**5,526.37**
	Units	**Amount**	**Total**
B. Scoping trip			
1. SALARIES			
Evaluation Director	0.00	1,598.94	0.00
INRM DCOP	0.00	1,442.72	0.00
Team Lead	8.00	1,078.53	8,628.26
Forest ecologist	0.00	1,023.42	0.00
Zoonosis consultant	0.00	1,134.24	0.00
In-Country Coordinator	0.00	354.26	0.00
Evaluation Manager/Specialist	15.00	817.74	12,266.12
Evaluation Assistant	0.00	404.47	0.00
Upenn MA Student	0.00	190.36	0.00
Upenn PhD Student	0.00	508.73	0.00
Interpreter	7.00	200.00	1,400.00
TOTAL Personnel	**30.00**		**22,294.38**
2. TRAVEL AND TRANSPORTATION			
International Airfare (Washington, DC, USA - CDI)	2.00	1,500.00	3,000.00
Airport Transfers	2.00	250.00	500.00
Visa	2.00	300.00	600.00
Medical	2.00	100.00	200.00
Travel Day Per Diem	4.00	78.75	315.00
Abidjan-San Pedro flight	2.00	150.00	300.00
CDI Day Transportation	9.00	50.00	450.00
M&IE, Abidjan, CDI	4.00	105.00	420.00
Lodging, Abidjan, CDI	4.00	210.00	840.00
M&IE, Other, CDI	18.00	76.00	1,368.00
Lodging, Other, CDI	18.00	80.00	1,440.00
CDI-Ghana Kumasi flight (through Accra)	1.00	500.00	500.00
M&IE, Other, Ghana	5.00	88.00	440.00
Lodging, Other, Ghana	5.00	120.00	600.00
TOTAL Travel			**10,973.00**
3. OTHER DIRECT COSTS			
Banking Fees	2.00	50.00	100.00
TOTAL ODCs (G&A Applicable)			**100.00**
G&A (applied only to Travel & ODCs)			1,577.90
TOTAL ESTIMATED COST			**34,945.28**
TOTAL ESTIMATED COST ALL ACTIVITIES (Labor + ODC)			**40,471.65**

Appendix E: Whole Project Theory of Change

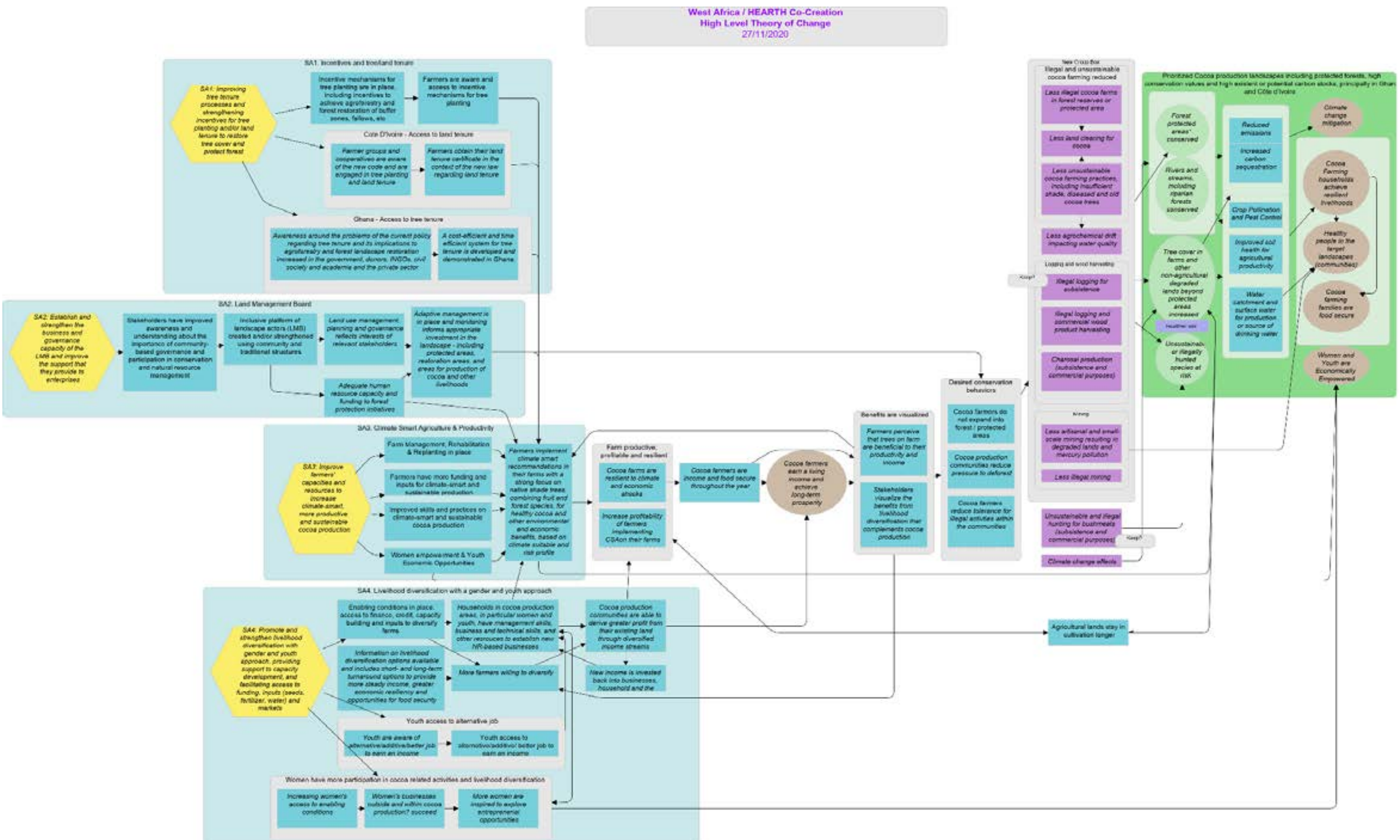

***Figure 9**. Co-creation High-level Theory of Changes*

Appendix F: Impact Evaluation Overview

IEs measure the causal impact of a program, or the difference in outcomes caused by a program or intervention and not by other external factors. IEs rely on a counterfactual or comparison/control group to rigorously distinguish causality from association. IEs seek to provide credible evidence on which policies and interventions are most effective for achieving development objectives. They are critical for rigorously documenting whether interventions achieve their expected objectives without generating unanticipated secondary effects that undermine the goals of the project.

IEs rely on a counterfactual or comparison/control group to rigorously distinguish causality from association. The designation of an evaluation as an impact versus PE ultimately depends on the validity of the control group or counterfactual. With the exception of the program of interest, the counterfactual areas should be as similar to the treatment areas as possible.

IEs employ experimental and quasi-experimental methods to identify treatment effects. Experimental approaches measure the causal impact of programs through randomized assignment (e.g., RCTs); (2) quasi-experimental measure causal impacts but without randomization (e.g., DID and statistical matching).[27]

IEs can be prospective where the research design is embedded in the intervention. The most rigorous prospective method for constructing the counterfactual is through random assignment (the RCT). IEs can also be retrospective, in which the control is constructed after the intervention has begun or concluded (i.e., the opportunity for pre-intervention baseline data collection has passed).

The treatment of interest for an IE can be designed for the community, household, or individual level. But different units of analysis are possible, such as focal species (e.g., rodents, bats, primates, ungulates, and pigs), a defined geographic area (e.g., forest or non-forest polygons), or farms. A minimum sample size is required for an IE to have the power to assess causality, and this depends on several factors, including the outcomes under investigation.

Finally, IEs can be designed to measure causal impact for a combination of interventions or seek to isolate the impact of one or more interventions. Conservation programs typically include a bundle of interventions not easily disentangled, such as bans on hunting focal species, habitat maintenance, and knowledge/outreach raising.

[27] Non-experimental approaches can answer descriptive questions about differences but cannot measure causality with the same degree of rigor or confidence. Non-experimental approaches include PEs, which generally include before-after comparisons without a rigorously defined counterfactual, and case studies, which include in-depth learning from an instance through extensive description and analysis.

QUASI-EXPERIMENTAL METHODS

Quasi-experimental methods utilize a counterfactual group that is not determined through a randomized process. Quasi-experimental strategies use data with a time and control group dimension to control for unobserved and observed fixed confounding factors. The comparison group is purposefully selected, constructed, or matched to create the best and most credible comparison for treatment areas. Although there is an underlying design behind the data collection, quasi-experimental methods rely on statistical corrections to ensure that the evaluation design is valid. Thus, quasi-experimental methods ultimately represent data-driven methods for evaluating the causal effect of a program; a large-scale data collection effort and econometric methods must be employed to ensure that selection bias between treatment and counterfactual groups is minimized. In theory, a well-designed quasi-experimental method can be a powerful statistical tool to minimize selection bias between treatment and control groups. However, they require stronger assumptions than randomized selection, and there are several methodological limitations because there is often selection bias in the selection of treatment areas.

Quasi-experimental methods are more common for conservation and land, resource, and governance interventions. For evaluating forest condition outcomes, projects apply a matching approach to develop synthetic controls of forest pixels. For the evaluation of settlement and household level livelihoods, well-being, governance, and health outcomes, a quasi-experimental methodology can be applied in treatment and comparison areas. Comparison areas and settlements may be identified from non-activity areas, matched on key biophysical and human population characteristics.

PERFORMANCE AND MIXED-METHODS EVALUATIONS

PEs, as defined in ADS 201, encompass a broad range of evaluation methods. They often incorporate before-after comparisons, but generally lack a rigorously defined counterfactual. PEs may address descriptive, normative, and/or cause-and-effect questions such as the following: questions about project or activity results or outcomes; implementation processes and their effectiveness; what has been sustained since a project or activity ended; how cost effective was the program compared to existing practice or another approach; was the project or activity viewed as being relevant, or given positive ratings by intended beneficiaries; were men/women, or elderly, or poor, differentially affected by the project or activity.

A mixed-method evaluation integrates two or more evaluation methods, usually drawing on both quantitative and qualitative data. Mixed-method evaluations may use multiple designs, for example incorporating both DID quasi-experimental methods and rigorous longitudinal research. They also may include different data collection techniques such as structured observations, key informant interviews, household surveys, and reviews of existing secondary data. Mixed-methods designs can strengthen an evaluation by (1) using different methods to answer different evaluation questions, or (2) using different methods to answer the same questions (increasing confidence in the validity/reliability of results). Generally, mixed-methods evaluations can provide a deeper understanding of why change is/not occurring and capture a wider range of perspectives. Table 11 below includes a high-level summary of different evaluation approaches.

Table 11. *Overview of Evaluation Approaches*[28]

Type	Approach	Description
Experimental	RCT	Random assignment (e.g., a coin toss or random number generator) determines who may participate in the program so that those assigned to participate in the program are, on average, the same as those who are not, in both observable and unobservable ways. Since the participants and nonparticipants are comparable, except that one group received the program, any differences in outcomes result from the causal effect of the program.
Quasi-Experimental	DID	Measure the before-and-after change in outcomes for the program participants, then subtract the before-and-after change in outcomes of the non-participants to find the relative change in outcomes for program participants. This methodology is only valid when if the program had not existed, the participants and non-participants would have experienced identical trajectories during the study period.
	Statistical Matching	Individuals who received a program are compared to similar individuals who did not receive it. Comparison groups can be constructed with different techniques including exact matching and propensity score matching. This methodology is only valid if characteristics that were not included in matching either do not affect outcomes or do not differ between participants and non-participants.
Non-Experimental	PE	PEs, as defined in ADS 201, encompass a broad range of evaluation methods. They often incorporate before-after comparisons but generally lack a rigorously defined counterfactual. PEs may address descriptive, normative, and/or cause-and-effect questions such as the following: questions about project or activity results or outcomes; implementation processes and their effectiveness; what has been sustained since a project or activity ended; how cost effective was the program compared to existing practice or another approach; was the project or activity viewed as being relevant, or given positive ratings by intended beneficiaries; were men/women, or elderly, or poor, differentially affected by the project or activity.
	Case Study	According to the widely used U.S. Government Accountability Office definition: "Case study as an evaluation method is a means of learning about a complex instance, based on a comprehensive understanding of that instance obtained through extensive description and analysis of that instance taken as a whole and in its context." Benefits of case studies include their flexibility of use, efficiency, dealing with multiple interventions, and addressing context. The evaluative case study is best used when the major questions are "how" or "why" questions.

[28] J-PAL, "Impact Evaluation Methods: What are they and what assumptions must hold for each to be valid," Accessed February 17, 2022, https://www.povertyactionlab.org/sites/default/files/research-resources/2016.08.31-Impact-Evaluation-Methods.pdf; USAID, "Evaluative Case Studies," 2013; USAID, "Performance Evaluation Designs," 2022.

Appendix G: Link between Land-use Change and Zoonotic Diseases Transmission

Land-use change and growing human populations are key drivers of emerging infectious diseases (Gottdenker et al. 2014; Jones et al. 2013; Olival et al. 2017). Land-use change and habitat conversion affect many of the risk factors for zoonotic spillover such as biodiversity loss, changes in the distribution of zoonotic host species, and increased human-wildlife contact. Land-use change alters the interface between recipient human hosts and reservoir hosts and can lead to increases in cross-host exposure to viruses. Land conversions can increase stress and reduce immune responses among wildlife which subsequently increases their pathogen load. Intensification of certain agricultural practices can increase resources for certain animal hosts of zoonotic diseases and decrease resources for others. Even the structure of farms impacts viral spillover risk, as smallholder farmers increase their forest access because of more interface or contact points.

Conservation, biodiversity, and land and resource governance employ a variety of interventions to reduce habitat conversion and forest degradation, including (1) interventions to improve the enabling environment for conservation, (2) interventions to change behavior/mitigate the threat of deforestation or degradation, and (3) actions to relieve direct stress on species and ecosystems through land, water, and wildlife management. Common conservation and biodiversity development interventions include protected area management, conservation enterprises, payment for ecosystem services, reforestation, law enforcement, wildlife demand reduction and behavior change campaigns, conservation planning, education and training, and institution strengthening, as well as market-based and direct economic payment schemes. Similarly, land and resource governance interventions include land-use planning, natural resource management, clarification of rights, policy and legal reform, awareness raising, etc.

Depending on the context, any one of these interventions may be relevant for mitigating viral zoonotic emergence through improvements to forest condition. Ecological restoration, through natural forest replanting versus monoculture tree plantations, is increasingly presented as a nature-based and cost-effective solution to mitigate climate change, biodiversity loss, and emergence of novel zoonotic pathogens (Brook et al. 2020). Restoration ecologists have shown that the creation of forests changes community structures (Watts et al. 2020), the movement of individual animals (Fuentes-Montemayor, Goulson, and Park 2011) and population densities (Watts et al. 2020), which suggests cascading implications for pathogen transmission. Forest restoration could also benefit human health by increasing biodiversity (in particular species that do not amplify viral zoonotic risk), lowering disease prevalence in reservoir populations, and reducing reservoir host-human contacts and hazard. Reforestation is understudied – but it is also an increasingly popular development intervention, and is the subject of an increasing number of current and planned research and evaluation initiatives.

Appendix H: Description of Laboratory Analysis of Soil Organic Carbon Storage, Granulometry and pH

Estimating the organic carbon (SOC) storage potential of soils

The fine mineral fraction of soil, which corresponds to granulometric clays (< 2 µm) and fine silts (2-20 µm), is a key component of SOC stabilization (Kleber et al. 2015). Organic carbon, derived from root exudates and soil microbial activity, binds to this fraction, and is permanently stabilized there.

Measurement of the granulometry of tropical forest soils

A particle size analysis will allow us to determine the size of the mineral constituents. For each sample, about 1.5 g will be weighed and submitted to three preparation phases: (i) de-carbonation with 10 percent hydrochloric acid, making sure that the pH does not fall below 2-3 to avoid attacking the clay particles; (ii) destruction of the organic matter by reaction with H2O; (iii) dispersion of the fine particles by adding sodium hexametaphosphate (x percent).

After pre-treatment, the soils will be passed through a Malvern Mastersizer 2000 laser sieve. The following particle size classes will be defined: sands (50 to 2000 µm), silts (2 to 50 µm) and clays (> 2 µm). The results are then expressed in mass percentage.

In situ or laboratory pH measurement

In situ, the pH of each sampled soil horizon can be determined using a HANNA-type field pH meter.

Naturally, tropical soils are strongly acidic (Dabin 1970), the natural alkalinization of soils or the increase in pH is an unexpected fact in these soils provided that the environment is in the presence of carbonation phenomena. Determination of pH can reveal ecosystems that accumulate carbon in organo-mineral form in the surface horizons (Martin et al. 2012). The pH will be determined by the electrometric method "glass electrode", in a soil/solution ratio of 1/2.5 in the laboratory.

Appendix I: Description of Water Sampling in-Situ and Lab Analysis

PHYSIO-CHEMICAL CHARACTERIZATION

The in-situ measurements will take into account routine physio-chemical parameters such as temperature, dissolved oxygen, pH, suspended solids, electrical conductivity, dissolved solids content and water turbidity. These parameters will be measured using a multi-parameter. In each sampling station these parameters will be measured in the first thirty centimeters, between 6h-7h and 15h-16h respectively for the worst and the most interesting conditions. The chemical parameters, notably nitrates, nitrites, ammonium, chlorine, total phosphorus and phosphates, will also be measured in the laboratory using standardized methods adapted from Rodier (1996).

BIO-ECOLOGICAL CHARACTERIZATION

Phytoplankton sampling will be carried out on the different sites. It will consist of directly taking 1L of water just below the surface with a pillbox. For the zooplankton sampling, 80 liters of water taken in the first 50 centimeters of the water bodies with a bucket will be filtered through a plankton net. The filtrate will be collected in pillboxes. In both cases, the pillboxes will be fixed immediately. Their content will be observed under a binocular magnifying glass for zooplankton and under a scanning electron microscope for phytoplankton.

The sampling of benthic macroinvertebrates will be carried out in each water body using a Van Veen bucket. The operation will consist of five grab strokes for sediment collection at each site. A dip net will also be used to collect live individuals from submerged leaves and wood. The sample obtained will be washed in the field with a 1 mm mesh sieve and poured into a white bottomed container for the collection of benthic organisms by forceps. The latter will be grouped by basin in pillboxes and fixed with 10 percent formaldehyde. In the laboratory, the identification and counting of organisms will be done under a binocular loupe.

CHEMICAL POLLUTION LEVEL

Pesticides tested in water and sediments will concern phenylureas (Fenuron, isoproturon, metoxuron, monolinuron, chlortoluron, buturon, methabenzthiazuron, metabromuron, and linuron) triazines (Metamitron, prometryne, terbutryne, cyanazine, propazine, terbuthylazine, atrazine, desisopropylatrazine, desethylatrazine, simazine) and other pesticides such as aldicarb and crimidine.

For the collection of water samples for pesticide analysis, a 500 mL borosilicate glass sample bottle previously washed with acid will be immersed to collect a water sample and then stored in a cooler

(4°C) in the dark until the laboratory. Pesticides in the water samples will be extracted by the liquid-liquid extraction method proposed by Åkerblom (1995). The extraction method consists of extracting pesticides from 500 mL of water, previously filtered on 0.45 μm pore size filter paper, by shaking, for 30 minutes, and decanting (3 times) a mixture of 500 mL of samples and 50 mL of dichloromethane. The organic phase containing the pesticides is then filtered over glass wool containing anhydrous sodium sulfate (30 g) to be free of any trace of water. The combined extract is then concentrated in a rotary evaporator (Bucchi) equipped with a water bath at a temperature of about 50°C and the solvent changed into cyclohexane. The volume of cyclohexane is adjusted to about 2 mL with acetone at a ratio of 9:1 (v/v) and is then ready for the purification phase. The purification phase is performed by packing on an SPE cartridge. The extract concentrated to 2 mL in the rotary evaporator (Bucchi) is fractionated on the SPE cartridge. The appropriate fraction, containing the pesticides, is evaporated and dissolved in a cyclohexane: acetone (9:1 v/v) mixture of about 2 mL and introduced into a vial for HPLC analysis.

Sediment samples (about 200-300 g) will be collected by a stainless-steel bucket and kept cool in aluminum foil or borosilicate glass vials, then in a cooler 4 °C) in the dark to the laboratory for freeze-drying. About 10 g of dry sediment will be crushed in an agate mortar and mixed with anhydrous sodium sulfate (10g), then reduced to a homogeneous powder. The powder is then extracted successively with 50 mL, then with 3 x 20 mL of a cyclohexane/acetone mixture (1:1 v/v) by mechanical stirring for about 5 minutes and then by ultrasound bath for 5 minutes. The extract was then filtered through glass wool containing about 15 g of anhydrous sodium sulfate and transferred to a separatory funnel. The flask containing the extract is then rinsed with 5 mL of the cyclohexane/acetone mixture (1:1 v/v) and the extract filtered over glass wool containing anhydrous sodium sulfate and added to the filtrate in the separatory funnel. 200 mL of saturated sodium chloride is then mixed with the filtrate in the separatory funnel and the organic phase containing the pesticides is extracted with 50 mL of a dichloromethane: cyclohexane mixture (15:85 v:v) and filtered over glass wool containing about 5 g of anhydrous sodium sulfate. The extract is then concentrated in a rotary evaporator equipped with a water bath at a temperature of about 50°C and the solvent changed to cyclohexane. The volume of cyclohexane is adjusted to about 2 mL with ethyl acetate in a 1:1 (v/v) ratio and is then used for the purification step identical to that of pesticides in water.

As for heavy metals in water, samples will be measured directly in the field thanks to a bottle prepared for the collection. Seven heavy metals and metalloids: mercury (Hg), lead (Pb), cadmium (Cd), aluminum (Al), iron (Fe), arsenic (As) and cyanide (CN) will be measured during this project.

For the determination of heavy metals in sediments, sediment samples will be collected by a stainless-steel bucket and kept cool in high density polyethylene (HDPE) bottles. In the laboratory, sediments will be dried at room temperature to constant mass, crushed, and then sieved to 63 μm. Aliquots of homogenized dry sediments (0.1 or 0.2 g) will be mineralized by the total digestion method. Seven heavy metals and metalloids: mercury (Hg), lead (Pb), cadmium (Cd), aluminum (Al), iron (Fe), cyanide (CN) and arsenic (As) will be analyzed by inductively coupled plasma optical emission spectrometry (ICP-OES). The accuracy and precision of the method will be validated by reference materials. Mercury will be analyzed directly in sediments without acid digestion by atomic absorption spectroscopy using a direct mercury analyzer (AMA-254, Altec, Czech Republic).

MICROBIOLOGICAL ANALYSIS

For microbiological analysis, water samples will be collected in 500 ml sterile glass bottles. All samples will be kept in a cooler containing dry ice and sent to the microbiology laboratory of the ocean research center (CRO) for analysis. All microbial analyses will be performed within 24 hours. The bacteriological analysis will consist of testing for aerobic mesophilic germs and bacteria indicative of fecal contamination such as coliforms (fecal including E. coli and total) and fecal Streptococci in the water samples.

METHODS FOR THE DETECTION OF BACTERIA IN WATER

- Mesophilic aerobic germs: by plating in the mass (PCA agar) of the sample diluted in a 1:10 ratio in physiological water. ISO 6222 standard

- Coliforms: 100 mL of water are filtered on a cellulose fiber filter and placed on the appropriate medium according to the method NF EN ISO 9308-1:2014 : "Water quality – Enumeration of Escherichia coli and coliform bacteria."

- Enterococci: 100 mL of water is filtered through a cellulose fiber filter and placed on the appropriate medium according to the method NF EN ISO 7899-2:2000: "Water quality – Detection and enumeration of intestinal enterococci – Membrane filtration method for waters with low bacterial content."