LORTA

Impact evaluation midline report for FP026

Sustainable Landscapes for Eastern Madagascar

January 2024

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Learning-Oriented Real-Time Impact Assessment Programme (LORTA)

IMPACT EVALUATION MIDLINE REPORT FOR FP026 - SUSTAINABLE LANDSCAPES FOR EASTERN MADAGASCAR

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FOREWORD

Scientific knowledge has the power to provide critical elements for project management. Following the awarding of the Nobel Prize in Economics in 2019 to Abhijit Banerjee, Esther Duflo and Michael Kremer for their experimental approach to addressing complex economic challenges in developing countries, the importance of measuring impact in development projects with experimental and quasi-experimental methods is widely acknowledged. The immense contribution of experimental and quasi-experimental methods to policymaking and resource allocation is well known. For an organization, learning from implementation in the field is very important, as it allows continuous improvement in project management. Rigorous impact evaluation allows increased transparency regarding the effects of investments. It also helps design and implement projects more effectively by providing a rigorous monitoring and evaluation system using innovative approaches and ensuring full stakeholder participation and ownership.

The Learning-Oriented Real-Time Impact Assessment (LORTA) programme of the Independent Evaluation Unit (IEU), Green Climate Fund (GCF), strengthens the capacity of accredited entities, implementing partners and project staff in assessing the impact of their interventions. The objective is to measure the change in key indicators that can be attributed to the project and inform stakeholders in real-time about the progress of project implementation. Since the beginning of the Sustainable Landscape in Eastern Madagascar project, in the Ankeniheny-Zahamena Forest Corridor (CAZ) and the Ambositra-Vondrozo Forest Corridor (COFAV), LORTA has been an essential part of the monitoring and evaluation system, using a rigorous scientific methodology to assess the project's impact through household surveys.

This midline report was completed to improve learning within Conservation International (CI) and the GCF and to highlight project achievements and impacts. We are grateful for the work of the LORTA team members from the IEU and Centre for Evaluation and Development (C4ED) and the support of staff from CI's Betty and Gordon Moore Center for Science, CI's Centre for Natural Climate Solutions, CI's GEF/GCF[1] Agency and across CI more broadly.

Bruno Rajaspera

Country Director

Conservation International Madagascar

[1] GEF stands for Global Environment Facility.

PREFACE

In 2018, the IEU initiated the LORTA programme, within which it collaborates with project teams funded by the GCF, local evaluation teams and academics. The LORTA programme incorporates state-of-the-art approaches for impact evaluations to measure results and raise awareness about the effectiveness and efficiency of GCF projects. The LORTA programme has a twofold aim: (i) to embed real-time impact evaluations into funded projects so GCF project task managers can quickly access accurate data on the project's quality of implementation and likelihood of impact, and (ii) to build capacity within projects to design high quality data sets for overall impact measurement. The purpose of the impact evaluations is to measure the change in key indicators that can be attributed to project activities. The LORTA programme reports on the impacts of GCF projects and helps GCF projects track implementation fidelity.

This USD 18.5 million GCF-funded project entitled Sustainable Landscapes in Eastern Madagascar (SLEM) started in 2018 is due to be completed by November 2024. It is implemented by Conservation International Madagascar. It aims to increase the resilience of smallholder farmers and reduce carbon emissions by implementing climate-smart agriculture and more sustainable forest management in two protected areas, the Ankeniheny-Zahamena Forest Corridor (CAZ) and the Ambositra-Vondrozo Forest Corridor (COFAV), which are the remaining large blocks of forest in eastern Madagascar, with 660,000ha covering 15 districts.

This project is considered crucial as it addresses one of the core causes of severe deforestation and land erosion in recent decades, namely unsustainable land-use practices. That is why it was chosen to join the LORTA programme from the beginning. Based on the baseline report[2] undertaken in 2020, the LORTA team has completed the midline report to see how impactful the project has been to local participants while implementation is still taking place.

[2] See https://ieu.greenclimate.fund/sites/default/files/document/sustainable-landscapes-eastern-madagascar.pdf.

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ABBREVIATIONS

2SLS	Two-Stage Least-Squares
C4ED	Center for Evaluation and Development
CARI	Consolidated Approach for Reporting Indicators of Food Security
CAZ	Ankeniheny-Zahamena Forest Corridor
CI	Conservation International
CI-M	Conservation International Madagascar
COBA	*Communautés de Base* (local community)
COFAV	Ambositra-Vondrozo Forest Corridor
DiD	Difference-in-Difference
DREDD	Regional Directorates for the Environment and Sustainable Development (*Directions Régionales de l'Environnement et du Développement Durable*)
EQ	Evaluation question
FSI	Food security index
GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse gas
HH	Household
ICC	Intra-cluster correlation
IE	Impact evaluation
IEU	Independent Evaluation Unit, Green Climate Fund
ITT	Intention-to-Treat
IV	Instrumental variable
LATE	Local Average Treatment Effects
LORTA	Learning-Oriented Real-Time Impact Assessment
MDES	Minimum Detectable Effect Size
MEDD	*Ministère de l'Environnement et du Développement Durable*
MGA	*Malagasy Ariary* (Madagascar's national currency)
OLS	Ordinary Least Squares
PICSA	Participatory Integrated Climate Services
RE	Random effects
SAP	Sustainable Agricultural Production
SLEM	Sustainable Landscapes in Eastern Madagascar
SPSS	Statistical Package for the Social Sciences
TLU	Tropical Livestock Units

ToC	Theory of change
VOI	*Vondron'Olona Ifotony*
WFP	World Food Programme

EXECUTIVE SUMMARY

The Sustainable Landscapes in Eastern Madagascar (SLEM) project (FP026) aims to increase the resilience of smallholder farmers and reduce carbon emissions by implementing climate-smart agriculture and more sustainable forest management in two landscapes around protected areas, the Ankeniheny-Zahamena Forest Corridor (CAZ) and the Ambositra-Vondrozo Forest Corridor (COFAV). These two corridors are the remaining large blocks of forest in the eastern part of Madagascar, with 660,000 hectares covering 15 districts. To develop resilient farming communities, SLEM directly supports vulnerable smallholder farmers to adopt sustainable agriculture techniques, strengthens the capacities of smallholders in climate mitigation and adaptation, and supports community-based organizations and local government.

Through the Learning-Oriented Real-Time Impact Assessment programme of the Independent Evaluation Unit of the Green Climate Fund, SLEM has been evaluated at midterm through a clustered phase-in design that relied on the randomization of the order in which each eligible cluster receives project activities. The midline evaluation of SLEM impacts enables us to gauge the project's progress towards its longer-term objectives. This study will be followed by an endline impact evaluation planned for late 2024.

The estimation of the SLEM midline impacts relied on comparing the outputs and intermediate outcomes of early beneficiaries with those of beneficiaries who receive project interventions later. Early beneficiaries, referred to as "Phase 1 households", received SLEM benefits in late 2019, while late beneficiaries ("Phase 3 households") started receiving benefits in mid-2022. This midline evaluation study uses baseline and midline primary data to focus primarily on adaptation indicators. Baseline data was collected in early 2019 on 1,822 households from local community associations. These households were interviewed again for the midline survey in late 2022. A total of 1,654 were successfully re-interviewed, resulting in an attrition rate of 9.2 per cent.

Our main estimation of the SLEM midline impacts consists of Intention-to-Treat (ITT) effects, measuring the impacts of belonging to the groups assigned to be early beneficiaries, irrespective of the actual receipt of SLEM interventions. Because of the imperfect compliance with this initial assignment, we also estimate the project's impacts on actual beneficiaries (specifically, Local Average Treatment Effects) using the random initial assignment as an instrumental variable.[3] Furthermore, we test the robustness of our results by exploiting the panel dimension of our data in Difference-in-Differences[4] estimates with random effects.

Midline results show significant improvements in households' short-term outcomes, with widespread adoption of a range of conservation agriculture practices, such as soil conservation, agroforestry, terracing and drought-resistance crops. Households who have received the SLEM interventions report greater food security as measured by the Consolidated Approach for Reporting Indicators of Food Security index.[5] They also report deriving less income from non-environmentally sustainable activities in both summer and winter.

[3] Instrumental variable regressions rely on an external source of variable in project participation (here, the random assignments of cluster of households into different implementation phases) to estimate the causal impacts of a project.
[4] DiD estimates compare the changes in outcomes between a group of intended beneficiaries and a group of non-beneficiaries before and after an intervention. This method accounts for initial differences between these two groups that remain stable over time.
[5] CARI is a summary indicator that captures multiple dimensions of food security quantitatively, systematically and transparently. It represents the overall food security status of households. It has four levels. A score closer to 1 denotes greater food security, and closer to 4 represents severe food insecurity.

Specifically, we find an increase in the proportion of Phase 1 households conducting farm livelihoods of 1 to 3 percentage points in the wet season and 2 to 3 percentage points in the dry season (both at the 1 per cent level). We also see an increase in the proportion of households conducting non-farm livelihoods (1 to 9 percentage points) in the wet season (significant at the 1 per cent level) and conducting off-farm livelihoods of 1 to 5 percentage points in the wet season (at the 1 per cent level). The increase in non-farm livelihoods appears to be driven by women-headed households.

The results from the midline evaluation show how a larger proportion of Phase 1 households are practising the following conservation agriculture techniques because of project interventions compared to Phase 3 control households[6]:

- Soil conservation (2 to 13 percentage points at the 1 per cent level, mainly driven by women-headed households)
- Agroforestry (2 to 6 percentage points at 1 per cent level, confirmed by 5 of 6 sets of estimates)
- Terracing (1 to 6 percentage points at 1 per cent level, mainly driven by women-headed households)
- Resistant crops (2 to 6 percentage points at the 1 per cent level)
- Off-season rice (5 to 20 percentage points at the 1 per cent level)
- Storage (2 to 9 percentage points at the 1 per cent level, confirmed by 5 of 6 sets of estimates)
- Savings groups (4 to 10 percentage points at the 1 per cent level)

Turning to agricultural production outcomes, the midline evaluation found that production of one crop was boosted by the project at midline, ginger, with production increasing by 23 to 36 percentage points at the 5 per cent level.[7]

Most importantly, the midline evaluation showed an improvement in food security status for treatment households as represented by the Consolidated Approach for Reporting Indicators of Food Security index (of 5 to 17 decimal points, significant at 5 and 10 per cent levels). The CARI index ranges from 1.00 (food secure) to 4.00 (severely food insecure). This finding needs to be carefully confirmed at endline, including triangulation with wider food security indicators.

Regarding forest conservation, the midline evaluation found a reduction in the proportion of households deriving income from non-environmentally sustainable activities of 1 to 3 percentage points in the summer and 4 to 7 percentage points in the winter (significant at the 1 per cent level).

Heterogeneity results highlight differential outputs and outcomes across households headed by women across the two landscapes and across the distance from the forest and initial levels of vulnerability. Notably, the results show how women-headed households and households in CAZ drive the adoption of soil conservation measures. Proximity to forests, which may serve as a proxy for a higher reliance on forest resources, and greater vulnerability at baseline partly moderate the impacts of the project on the adoption of these practices.

Overall, the promising outcomes observed in the midline results for short-term impacts suggest a positive trajectory towards achieving the SLEM's medium-term and longer-term objectives. This assumption will be tested by measuring the project's longer-term impacts in an endline survey planned for 2024 with a specific focus on mitigation, as well as an assessment of the efficiency of the intervention.

[6] The report presents the range of impact estimates from six specifications. As a result, the midline estimates offer a range of impacts based on these different analytical approaches.

[7] This finding is of limited importance as ginger is no longer promoted by the project because it can reduce soil fertility.

I. INTRODUCTION AND CONTEXT

1. Madagascar remains one of the poorest countries in Africa, with 75 per cent of the population living on less than USD 1.90 a day in 2019 (World Bank, 2020) and a per capita gross national income (in constant 2015 USD) of USD 471.95 in 2019 (World Bank, 2019). The country is particularly vulnerable to climate hazards. It has been ranked twelfth out of 183 countries in terms of the Climate Risk Index for the period 2000-2019 (Eckstein and others, 2019), and the severity of climate hazards is expected to increase in the following years (*Deutsche Geselleschaft für internationale Zusammenarbeit*, 2021). In terms of impacts on natural systems, Ingram and Dawson (2005) have highlighted how Madagascar's vegetation cover is highly correlated with the El Nino Southern Oscillation. This meteorological phenomenon is likely to become more frequent with climate change, leading to thinner vegetation cover and increasing the likelihood of droughts and wildfires. More recent estimates by Hending and others (2022) suggest that forest cover is likely to reduce under four climate scenarios by 2080 due to higher temperatures and more variable precipitation (with one exception in the northwest of the country).
2. The two remaining large areas of forest in the eastern part of Madagascar are the Ankeniheny-Zahamena Forest Corridor (CAZ) and the Ambositra-Vondrozo Forest Corridor (COFAV). CAZ has 370,000 ha covering five districts, whereas COFAV has 290,000 ha covering 10 districts. Current patterns of unsustainable use of forest resources threaten these natural areas. One reason for deforestation is the lack of alternative sources of livelihoods for populations in situations of severe economic vulnerability. Farmers' livelihoods are further constrained by low levels of soil productivity, poor access to markets and a high sensitivity to climatic shocks. The pressure on natural resources is further amplified by rural populations' dependency on agriculture and the increasing scarcity of agricultural land in the face of demographic growth, resulting in encroachments of forest areas. Households have few options to diversify their sources of income, and those involved in livestock rearing suffer from high levels of livestock disease.
3. The Sustainable Landscapes for Eastern Madagascar (SLEM) project was developed to respond to the critical need for reducing the vulnerability of households to climatic shocks and their dependence on forest resources in CAZ and COFAV, thereby safeguarding their forest areas. This USD 18.5 million project, started in 2018 and due to be completed by November 2024, is funded by GCF and implemented by Conservation International Madagascar (CI-M). The project aims to increase smallholder farmers' resilience and reduce carbon emissions by implementing climate-smart agriculture and more sustainable forest management.
4. CAZ and COFAV are characterized by a mosaic of lowland, humid tropical forests and agricultural lands. CAZ and COFAV areas are extremely rich in diverse and endemic species. In CAZ, over 2,043 species of plants have been identified, of which 85 per cent are endemic. These forests provide a habitat for 15 species of lemurs, of which several are threatened, 30 other species of mammals, 129 species of amphibians and 89 species of birds. In COFAV, there are over 800 species of plants and 300 species of animals, including 17 species of lemurs, of which two are highly endangered. Moreover, those sites are important for their water provision and forest cover and are characterized by a high dependency of local populations on forest resources for their livelihood (*Ministère de l'Environnement, de l'Ecologie, de la Mer et des Forêts* and Conservation International, 2015). They are also important sources of minerals, gemstones and gold. These two areas have been officially protected since 27 April 2015 (*Ministère de l'Environnement, de l'Ecologie, de la Mer et des Forêts*, 2015a and 2015b).

5. Most of the population in the CAZ landscape (surrounding the external boundaries of the protected area) is living in a precarious situation, with household monthly earnings averaging 300,000 MGA (Malagasy Ariary, Madagascar's national currency), or around 113.98 USD[8] (*Ministère de l'Environnement, de l'Ecologie, de la Mer et des Forêts* and Conservation International, 2015). People surrounding CAZ collect yams, sweet potatoes, honey and forest material for handicrafts. They also collect shrimps, fish and eels from local waterways. Forest products, including firewood, are also complementary income-generating activities. The population in CAZ is primarily practising agriculture for their consumption. The Sihanaka and the Bezanozano are occupying the territory in the western part of the corridor. The Betsimisaraka ethnic group is living in the eastern part. The main livelihood activity is agriculture. However, they often face a lean season every year, which forces them to search for food in the forest, such as wild tubers, game, fish, and honey (*Ministère de l'Environnement, de l'Ecologie, de la Mer et des Forêts*, 2012).
6. The main ethnic groups in the COFAV landscape are the Tanala, Betsileo, Bara and Sahafatra.[9] Most people cultivate rice, cassava, coffee, beans, lychees and bananas. In addition, they produce a local alcoholic beverage (rhum) and collect crayfish. Since 2013, there have been some changes in how people cultivate rice in this region. Some households have abandoned irrigated rice cultivation and now practice slash-and-burn agriculture due to a lack of fertility. Cassava and bananas are also mainly for household consumption. Sugar cane is also cultivated for traditional brown sugar production or for brewing alcoholic beverages. Ginger cultivation has become popular in the past few years. Vanilla and pepper were introduced, as these crops are well adapted to the local climate.
7. The climate in the eastern part of Madagascar is tropical, with a dry season from April to October and a rainy season from November to March. Smallholder farmers in these places are affected by frequent cyclones that cause heavy rain, strong winds and flooding, which reduce their harvest, lead to food shortages and further exacerbate deforestation. In the last 10 years, both corridors have experienced several anomalies in precipitation patterns with several periods wetter than usual and some drier than usual, especially in the most recent years (Intergovernmental Panel on Climate Change, 2014). The frequency and intensity of cyclones are expected to increase by the end of 2100 because of climate change (Hending and others, 2022).
8. Harvey and others (2014) assessed smallholder vulnerability to sources of risk in three areas of Madagascar, including CAZ and Nosivolo in the east of the country. Their findings highlight how smallholders rely heavily on agriculture, suffer from long-term food insecurity, are often relatively distant from urban services and generally do not have easy access to formal safety nets. For example, survey evidence from 600 households illustrates how smallholders are subject to substantial crop losses and limited income. Cinner and others (2022) offer recent estimates from a survey of 339 households in coastal communities in Madagascar, which highlight the chronic poverty of many smallholder households and how climate effects will be differentiated across and within communities. Weiskopf and others (2021) outline how tackling forms of vulnerability relies on the sustained engagement of communities with multiple stakeholders across sectoral and institutional boundaries to relieve multiple binding constraints.
9. In addition to the challenges described above, the population of CAZ and COFAV areas have also suffered from the consequences of the COVID-19 pandemic since 2020 (Green Climate Fund and Conservation International, 2021). The economic impacts on SLEM project beneficiaries were substantial, with movement and trade between towns and the larger cities of Madagascar halted, public transportation banned and access to markets significantly reduced. Prices for all goods

[8] To estimate the value in USD, we used the 2015 exchange rate obtained from www.oanda.com.
[9] Personal communication, Conservation International Madagascar.

increased. Due mainly to this economic insecurity, more deforestation occurred in the protected areas of CAZ and COFAV in 2020 than in 2019 (Green Climate Fund and Conservation International, 2020). To secure food and income, communities illegally cleared land, sought out non-wood forest products, timber and pursued mining opportunities in the SLEM project's target areas. The consequences of the COVID-19 pandemic on household vulnerability and their knock-on effects on deforestation reinforce the SLEM project's importance.

10. This report presents the result of the midline evaluation of SLEM impacts. Through the Learning-Oriented Real-Time Impact Assessment (LORTA) programme of the Independent Evaluation Unit of the Green Climate Fund, SLEM has been evaluated at midterm through a clustered randomized phase-in design that relied on the randomization of the order in which each eligible cluster receives project activities. This study uses longitudinal primary data on 1,654 households collected in 2019 and 2022. The midline evaluation of SLEM impacts enables us to gauge the project's progress towards its longer-term objectives. This work will be followed by an endline impact evaluation planned for mid-2024.

11. The present document is organized as follows. Section II describes the SLEM project, its implementation progress and the project's theory of change (ToC), as well as introducing key evaluation questions and indicators used in this study. Section III describes the midline evaluation strategy. Section IV presents the results, followed by a discussion in section V. Section VI appraises the study's limitations, while Section VII presents the study's concluding remarks.

II. PROJECT (INTERVENTION) DESCRIPTION

12. Following the effectiveness of the GCF Funded Activity Agreement in 2018, the SLEM (FP026) project started.[10] This intervention aims to support and promote the implementation of sustainable landscape measures to enhance the resilience of smallholder farmers, reduce greenhouse gas (GHG) emissions from deforestation, and make climate-smart investments in agriculture in CAZ and COFAV areas. CI-M implements the project and has a budget of USD 18.5 million for five years (2018-2023) with a two-year no-cost extension to 2025.[11] The SLEM project collaborates with the Ministry of Environment and Sustainable Development (MEDD), notably regarding the development of management plans for CAZ and COFAV-protected areas, law enforcement regarding the use of natural resources, forest fire monitoring and the monitoring of carbon emissions.

13. The project's overarching goal is to implement sustainable landscape measures to enhance the resilience of smallholder farmers, reduce GHG emissions from deforestation, and make climate-smart investments on agricultural lands. The sustainable landscape measures consist of a portfolio of activities, among which two are the focus of the impact evaluation (IE): adaptation and mitigation activities. Adaptation activities include the provision of training, inputs and mentoring to smallholder farmers to promote sustainable agricultural production, ecosystem-based adaptation, alternative sources of livelihood and support to market access and creation of local committees. The mentoring primarily consists of advice from lead farmers, field agents, and technicians from the directorate of agriculture and livestock through Sustainable Agricultural Production (SAP) and demonstration plots. Target communities are invited to work alongside the project team to develop proposals for climate risk coping mechanisms based on their needs and interests related to the project's main objectives. Regarding mitigation activities, the project provides training, stipends and equipment to conduct forest patrolling activities and physically demarcate the limits of the protected areas. Local *Vondron'Olona Ifotony* (VOI – local forest management groups), also referred to as *Communautés de Base* (COBAs – local communities), have conducted forest patrolling activities within local forest management practices.[12] To improve forest control, project staff have also been using drones. Where significant illegal activities occurred, multiple stakeholders conducted forest control measures under the lead of the *Directions Régionales de l'Environnement et du Développement Durable* (DREDD – Regional Directorates for the Environment and Sustainable Development) law enforcement agency. Furthermore, forest nursery workers have been collaborating with the project to produce forest and agroforestry seedlings, while local communities have been participating in tree planting for forest restoration.[13]

14. The SLEM project addresses one of the core causes of severe deforestation and land erosion in recent decades, namely unsustainable land-use practices. The project aims to raise awareness of climate-related risks and climate-smart agricultural practices through various activities. It provides training and inputs to encourage people to adopt practices that prevent land and forest degradation while improving smallholder farmers' resilience and food security. The SLEM project aligns with

[10] The project was approved in October 2016.
[11] EIB was an accredited entity but withdrew its participation from this project in June 2020.
[12] Some VOIs (local communities) have a contract with MEDD to manage local forests and conduct forest patrolling. These VOIs receive training from DREDD and the project on how to manage and patrol local forest near their villages.
[13] The project also provides information and training on adaptation and mitigation measures to local communities. In addition, local communication campaigns promoting success stories have been conducted, including through local magazines (e.g. Soan' Ala), television and radio.

the Climate Change National's documents, such as The National Action Plan for Climate Change Adaptation and the National Policy for Action on Climate Change, REDD+[14] strategy.

15. The project has two specific objectives:
    - Improving climate change resilience and the food security of vulnerable farmers surrounding the forest corridor landscapes.
    - Reducing carbon emissions within the landscapes through forest protection and restoration.

16. The project activities target 23,800 households, including members of COBAs for local forest management and local associations (notably, women associations and people affected by the creation of protected areas groups). COBAs were created under Decree No. 2000-027 in which local communities are responsible for managing renewable natural resources. Volunteers create these COBAs from either hamlets of the same village or several villages. Most COBA members are involved in agricultural activities and rely on forest resources.[15] Since 2012, the *Ministère de l'Environnement et du Développement Durable* (MEDD – Ministry of Environment and Sustainable Development) has delegated CI to oversee the Protected Areas Management of both CAZ and COFAV. In this respect, the SLEM project is responsible for supporting the management plans of CAZ and COFAV-protected areas, supporting the sustainable use of natural resources, forest protection and reducing carbon emissions.

17. The SLEM project was onboarded into the LORTA programme in 2019. The implementation of adaptation activities follows a staggered roll-out, originally organized in three phases over three years for COBA or VOI selected for LORTA. In 2019, the first cohort of COBAs (Phase 1) received the planned interventions. In 2020, the implementation of activities in the second cohort of COBAs (Phase 2) was not completed because of the impact of the COVID-19 pandemic on travel restrictions. The initial implementation of adaptation activities in the third cohort of COBAs (Phase 3), planned for 2021, was postponed to 2022. First and third phase COBAs were selected randomly from an eligible pool of COBAs, such that third phase COBAs can serve as a rigorous comparison group for first phase COBAs during the first years of SLEM implementation.[16] A complementary comparison group was identified outside the zone of SLEM intervention to measure the project's longer-term impacts. The project's output level indicators obtained from the GCF Annual Performance Report (Green Climate Fund and Conservation International, 2020, 2021, 2022) are presented in Table II–1.

18. Project implementation has been greatly affected by the COVID-19 pandemic. Due to the risk of spreading the pandemic, CI-M followed government instructions and imposed COVID-19 travel restrictions for the entire country between March 2020 and December 2020. Therefore, only a small subset of the planned activities was implemented during this period. These activities included a limited number of forest control and local forest patrolling missions and a few assessment missions in late 2020. In 2020, no new household beneficiaries received goods. Restricted travel to the field reduced forest area patrolling, with 1,104 out of 4,400 target forest patrol missions conducted in

[14] REDD+ stands for Reducing emissions from deforestation and forest degradation.

[15] These COBAs are created by a group of volunteers from either hamlets of the same village or from several villages. Management transfer agreements are signed between each COBA, the Malagasy government and the municipalities attached with the COBA, the responsibilities of each entity are defined in the agreement. The agreement initially has a duration of three years. If the COBA respects its obligations, the agreement can be renewed. Members of the COBA have rights over the sustainable use for natural resources within multiple use forest zones for various purposes (medicine, house building, consumption,) through management transfer contracts over the local forest as provided by government. In return, members of the COBA have the responsibility to protect these resources. Some of the COBA members may benefit from additional ecotourism activities. Most COBA members are involved in agricultural activities and rely on forest resources.

[16] Phase 2 households were excluded from the study to expand the timespan covered by the evaluation. Furthermore, Phase 2 also includes groups that were not eligible for the randomization. More information is provided in the section III.A.1.

2020 by 69 COBAs. Limited patrolling, combined with social and economic factors emanating from the COVID-19 pandemic, led to an increase in the illegal exploitation of forest natural resources and illegal mining.

19. Nevertheless, during this period, the project continued activities that did not require travel. These activities included the revision of the community in-kind agreement proposals, procurement planning, data analyses, reporting, community patrols of adjacent forest areas, support payments to farmer trainers, community development of tree and food-crop nurseries, and working with the government to begin the development of a Climate Change Trust Fund. Table II–1 illustrates that the project was on track to meet its end-of-project targets as of April 2022.

20. The project applied an Environmental Social Management Framework to ensure its activities respect local people and do not harm the environment and natural habitat. In addition, each activity implemented by the project is gender sensitive. The framework includes screening project activities, including potential activities, concerning the GCF/IFC[17] procedures. In summary, the project activities are expected to lead to specific minor or low-risk social and environmental impacts for most of the proposed activities. Some potential medium social and environmental risks for activities are either of a small-scale or can also be addressed with appropriate appeasement measures.

Table II–1. Progress on SLEM implementation regarding the main indicators for adaptation and mitigation

Project/programme indicators (mitigation/adaptation)	Current value (Apr 2022)	Target by the end of the project
A7.1. Number of beneficiary households adopting sustainable agriculture techniques	15,813	19,992 household beneficiaries adopted sustainable agriculture techniques
A7.3. Resilience to climate induced shocks and other risks is improved by supporting farmer-led, gender sensitive analysis, planning and risk management % of beneficiary households losing more than 25% of crops (fields, crops) after climate shocks		40% of beneficiary households losing more than 25% of crops
A7.4.a. Hectares of critical habitats managed sustainably by the local communities within the agricultural landscape	8,425 ha agroforestry areas managed sustainably by the local communities[18]	10,051ha
A7.4.b. Hectares of critical habitats restored within the agricultural landscape	2,620 ha agroforestry restored in both CAZ and COFAV[19]	3,570 ha
A8.0. Strengthened awareness of climate threats and risk reduction processes Number of people informed of the potential impacts of climate change and the range of possible responses	168,669[20] people informed	150,000
A8.1. Strengthened capacity of government employees, local conservation and development	153,089 men and women trained	115,019

[17] IFC stands for International Finance Corporation.
[18] Sustainable agroforestry areas obtained through the analysis of satellite imagery.
[19] This has been via agricultural landscape restoration via the provision of in-kind grants.
[20] This figure does not include people informed via project communication through television, radio stations and national newspapers.

PROJECT/PROGRAMME INDICATORS (MITIGATION/ADAPTATION)	CURRENT VALUE (APR 2022)	TARGET BY THE END OF THE PROJECT
NGOs, farmer groups and local communities to implement mitigation and adaptation measures to achieve Climate-smart Landscapes.		
Number of people informed about climate change, sustainable agriculture and environmental issues	164,277	150,000
M9.2. Improved forest management as outlined in the CAZ and COFAV management plans and emission reductions verified Tons of carbon dioxide equivalent (tCO2eq) reduced or avoided due to sustainable management of forests and conservation and enhancement of forest carbon stock	7,484,902t CO2e[21]	9,000,000tCO2e
M9.4. Forest restoration on degraded lands within the CAZ and COFAV-protected areas/carbon project areas # ha restored	2,854 ha	2,500 ha

Source: Green Climate Fund and Conservation International (2022)

A. THEORY OF CHANGE

21. Two theories of change, one for adaptation and one for mitigation activities were developed collaboratively by the LORTA and SLEM project teams. These relatively simple theories of change were developed at the start of the evaluation by all stakeholders to better understand how the project's inputs and activities are intended to contribute to the project's overarching goals. These ToCs and their underlying assumptions are presented separately in the following subsections. The project's complete ToC is available in the baseline report.[22]

1. COMPONENT 1: CLIMATE ADAPTATION ACTIVITIES

22. Figure II–1 summarizes the five stages of a ToC across inputs, activities, outputs, outcomes and goals.

1) Inputs

23. GCF grant and CI funds were allocated for purchasing goods and training eligible farmers to implement sustainable agriculture production. Training modules were developed, and in-kind grants provided for seeds, seedlings of food and cash crops, livestock, juvenile fish and small agricultural equipment.

2) Activities

24. Adaptation activities consist of on the ground training on sustainable agricultural practices and climate change communication materials, providing inputs and continuous technical assistance on alternative livelihood strategies and conservation agriculture practices. The conservation agriculture practices include agroforestry and tree planting, micro-irrigation and drainage canals, intercropping and multi-cropping systems, off-season rice cultivation, mulching, no-tillage agriculture and terracing. Each COBA identified these activities with project staff to assist with their needs. The

[21] In 2022, the project reduced emissions by 1,675,000 tC02e.
[22] The baseline report offers greater detail on assumptions, co-benefits and unexpected outcomes.

implementation of these activities is measured by collecting information on the number of household beneficiaries and lead farmers trained, the number of households that received in-kind grants and adopted sustainable agricultural practices and the hectares of agroforestry managed and crop yields. The completion of these activities depends on the farmers' willingness to adopt SAP, the availability of suitable human capital in the project intervention area and the incidence of climate hazards, such as cyclones, that might adversely impact the project. These activities are complemented by the distribution of weather bulletins to lead farmers and leaders of associations in the municipalities in the intervention's target area. These leaders are expected to share this information orally with the rest of the group or community.

3) Outputs

25. The adaptation activities are expected to result in the dissemination of risk reduction practices and enhanced knowledge of alternative sources of livelihoods, ranging from receiving sustainable agriculture inputs to in-kind grant support and technical assistance. The successful completion of the output stage has been measured in terms of the number of households participating in the trainings, receiving inputs and assistance, the feedback received on the clarity of the material presented, the adoption of sustainable agricultural practices and the knowledge of participants regarding climate change and risk reduction strategies. The completion of these outputs has relied on farmers' interest and availability to participate in the trainings and beneficiaries' willingness to adopt SAP practices. This has assumed that the training schedule does not conflict with farmers' productive activities and that they are aware of the potential benefits of the techniques promoted in the trainings. The effective transfer of knowledge has relied on the quality of the trainings and their appropriateness to and relevance for the targeted farmers.

4) Outcomes

26. If the target group benefits from the elements described in the output stage, we expect a certain number of households to do the following:

- Implement these new practices
- Increase their production of subsistence and cash crops
- Use the provided inputs to rely on assistance when needed
- Diversify their sources of livelihoods
- Utilize weather forecasts and market information
- Adapt their practices accordingly

27. The successful completion of the outcome stage relies on farmers' perceptions of these new practices, particularly that the perceived benefits exceed the perceived risks. There also should be no other barrier than knowledge, access to inputs and access to weather information that may prevent adopting the practices. Finally, weather information should be disseminated through media that rural populations can effectively access.

5) Goals

28. The main end-of-project goals for the adaptation activities are increased crop productivity, greater food security and decreased vulnerability to climate-related hazards. Due to the nature of the interventions, these goals are expected to be realized in the longer term, between five and 10 years after benefiting from the project. To contribute to these goals, the SLEM project is expected to lead to a long-term change in agricultural practices and sources of income. The sustainability of the project's impacts relies on the continuous availability and affordability of required inputs, the farmers' ability to keep implementing these practices in the prescribed way without further technical advice from the project team, and the effective reduction in farmer dependency on weather. Achieving these goals faces additional challenges stemming from inadequate road infrastructure

maintenance, rising insecurity levels and the impacts of climate change. These factors could potentially undermine the effectiveness of the proposed activities in the times ahead.

Figure II–1. Theory of change of adaptation activities

Source: LORTA team

2. Component 2: Climate mitigation activities

29. Figure II–2 summarizes the five stages of a ToC for mitigation across inputs, activities, outputs, outcomes and goals.

1) Inputs

30. GCF grant and CI funds are allocated for hiring field agents and local trainers, purchasing equipment, paying stipends to local patrollers and training local patrollers. Project funds also lead to restoring forest and implementing agroforestry, identifying nursery workers, and training and equipping nursery workers, including developing training modules.

2) Activities

31. Mitigation activities consist of providing stipends and equipment to community patrollers, physically demarcating the limits of the protected areas and training patrollers and associations in forest legislation. Successful implementation of these activities relies on the availability of sufficient project funds, access to good quality equipment and suitable human capital. Mitigation activities also aim to strengthen local capacity in technical, legal and management aspects of restoration. The project provides training to develop tree nurseries and tree plantations following the national policies for forest restoration management.

3) Outputs

The mitigation activities are expected to result in patrollers receiving per diems and equipment, enhanced knowledge of forest legislation, increased awareness of sustainable forest management and enhanced visibility of the borders of protected areas. Effective transfer of knowledge requires quality training and a high participation rate.[23]

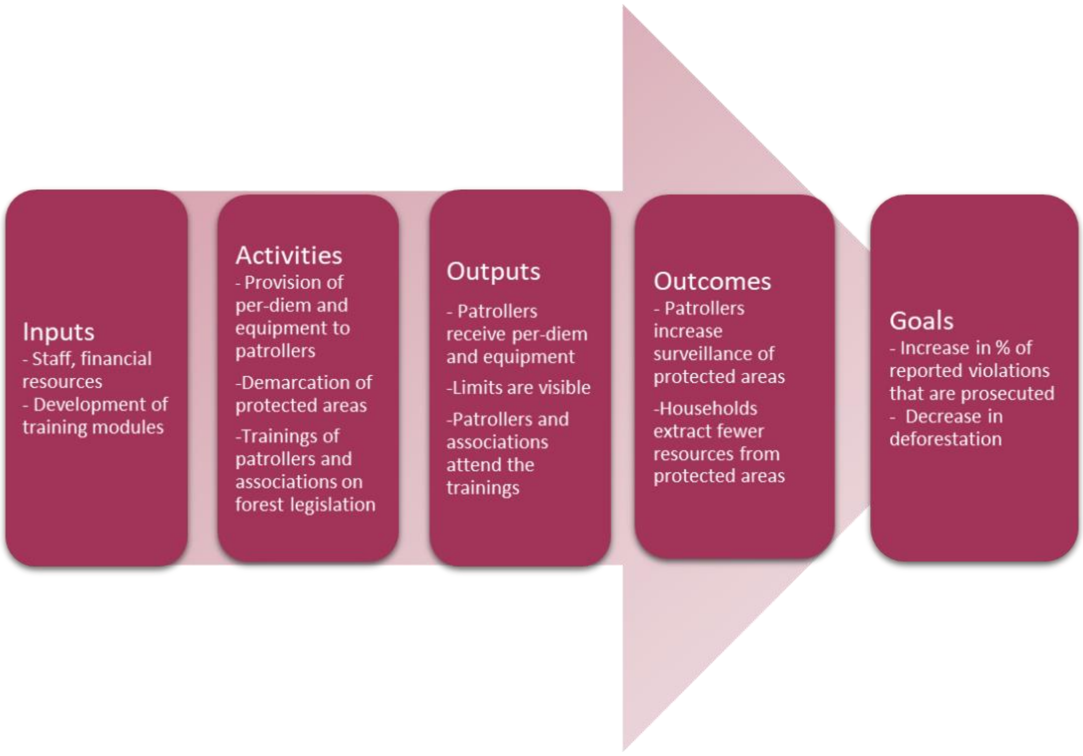
4) Outcomes

If the target group benefits from the elements described in the output stage, we expect rangers to increase their surveillance of protected areas and households to extract fewer resources from these areas. The successful completion of the outcome stage relies on patrollers receiving sufficient incentives to conduct effective patrols of forest areas and their willingness and ability to stop or signal violations without fearing for their safety.

5) Goals

The main goals of the mitigation activities are an increase in the percentage of reported violations that are prosecuted and a reduction in deforestation. To contribute to these goals, the violations reported to the Forestry Department must be followed up and prosecuted. The likelihood that violators are prosecuted and incur penalties should be significant enough to discourage households from over-exploiting forest resources. Finally, households need to be able to find alternative income sources to forest exploitation.

Figure II–2. Theory of change of mitigation activities



Source: LORTA team

[23] The evaluation team acknowledges these outputs could have a closer connection to the project log frame.

B. Evaluation questions and indicators

32. The IE of the SLEM project has sought to answer the following evaluation questions about adaptation activities. A complete list of indicators and subindicators is included in Appendix 1.

Table II–2. Adaptation evaluation questions and indicators

Activity	Question	Indicator
Adaptation	EQ1. Does implementing adaptation activities lead to an increase in the number of **livelihood strategies** used?	EQ1.1. Livelihood diversification
		EQ1.2. Number of crops and livestock used by the household
	EQ2. Does implementing adaptation activities lead to an increase in the **number of conservation agriculture practices implemented**?	EQ2.1. Implementation of conservation agriculture practices
		EQ2.2. Number of conservation agriculture practices used by farmers
	EQ3. Does implementing adaptation activities lead to a reduction in damages to livelihood products following **climate hazards**?	EQ3.1. Damages in agricultural, forest and livestock products following climate hazards
	EQ4. Does implementing adaptation activities lead to an increase in **agricultural (crops and livestock) production**?	EQ4.1. Quantities produced of three main crops, animals, forests/tree products
		EQ4.2. Share of the agricultural production not used for household consumption
	EQ5. Does implementing adaptation activities lead to an increase in **income/expenses**?	EQ5.1. Household expenditures
		EQ5.2. Income
	EQ6. Does implementing adaptation activities lead to an increase in **food security**?	EQ6.1. Food security index based on food consumption, food expenditure shares and the number of strategies to cope for a lack of food (See Appendix 3 for details on its calculation)
		EQ6.2. Number of days members of the household did not eat three meals a day
	EQ7. Does implementing adaptation activities lead to a reduction of households' **vulnerability to climate hazards**?	EQ7.1. Vulnerability index based on exposure, sensitivity and adaptive capacity of farmers (See Appendix 4 for details on its calculation)
		EQ7.2. Strategies used to respond to hazards
	EQ8. Does improving food security depend on the sustainable management practices implemented in farms?	EQ8.1. Food security index based on food consumption, food expenditure shares and the number of strategies to cope for a lack of food (See Appendix 3 for details on its calculation)
	EQ9. Does reducing climate vulnerability depend on the sustainable management practices implemented in farms?	EQ9.1. Vulnerability index based on exposure, sensitivity and adaptive capacity of farmers (See Appendix 4 for details on its calculation)

Source: LORTA team

33. CI used the Consolidated Approach for Reporting Indicators of Food Security (CARI) index developed by the World Food Programme (WFP) to assess household food security and ensure alignment with other agencies. CARI is a summary indicator that helps capture multiple dimensions of food security quantitatively, systematically and transparently. Here, three food security indicators commonly used by the WFP (food consumption,[24] food expenditure,[25] and coping strategy[26]) are combined into the Food Security Index (FSI). The FSI represents the overall food security status of households and is categorized in an ordinal variable consisting of four levels: (i) food secure, (ii) marginally food secure, (iii) moderately food insecure, and (iv) severely food insecure. Following the CARI methodology, the FSI is calculated using the averages of the three subindexes with more weight on the food consumption score than the food expenditure and coping strategy scores.

34. To assess the climate change vulnerability of the target population, CI developed a climate change vulnerability index based on three subindices: exposure, sensitivity and adaptive capacity. The voluminous literature on vulnerability indicates how susceptibility to loss based on damaging fluctuations can consist of (i) exposure to shocks or stresses, such as meteorological events,[27] (ii) sensitivity to these damaging fluctuations, in terms of impacts on natural systems such as ecosystems, and human systems such as agricultural production, and the operation of markets,[28] and (iii) the adaptive capacity of households, including forms of human, social, financial, physical, and natural capital, entitlements, institutions and capabilities, knowledge and information, and decision-making and governance (Blaikie and Brookfield, 1987; Moser, 1998; Ellis, 2000). Recent contributions to measuring vulnerability and resilience are bifurcated between those that take their point of departure from climate science and adaptation literature[29] and those based on economic work addressing poverty traps and resilience.[30] A further strand in the literature utilizes different statistical approaches, such as principal components analysis, to create a resilience index.[31] CI's approach has been to create composite indices for each of the three components (see Appendix 4) using an approach that is intelligible to all stakeholders. All variables were categorized in quartiles, ranked from 1 to 4 (1= low, 4=high) and summed for each subindex. A higher number represents higher exposure and sensitivity but lower adaptive capacity (this third component is inverted). CI then aggregated these 'subindices' into a final climate change vulnerability index for each household. Equal weighting has been used in this report.

35. The IE of the SLEM project has sought to answer the following evaluation questions regarding mitigation activities. A complete list of indicators and subindicators is included in Appendix 2.

[24] The food consumption score is an indicator for dietary consumption that includes both quantity and quality considerations. Quantity considerations include the frequency of consumption, specifically the number of days, of eight food groups consumed by a household during the 30 days before the survey. Quality considerations include dietary diversity based on the number of different food groups consumed over the last 30 days.
[25] The food expenditure scores estimate the proportion of the household budget spent on food. It is based on food expenditure shares, with the most food insecure spending greater than 75% of their budget on food and food secure spending less than 50%.
[26] The coping strategy score focuses on the frequency and severity of changes in food consumption by households. It assesses whether any member in their households engaged in 10 coping strategies (four stress strategies, three crisis strategies, and three emergency strategies) because there was not enough food or money to buy food during the past 30 days. The 10 coping strategies were selected using CARI and based on known strategies used in the region from previous household surveys.
[27] See Chambers (1989).
[28] See Sinha and others (1999).
[29] See Adger (2006); Folke (2006); Béné and others (2014; 2017); Speranza, Wiesmann and Rist (2014).
[30] See Carter and Barrett (2006); Prowse and Scott (2008); World Food Programme (2014a; 2014b); Cissé and Barrett (2018); d'Errico and others (2020).
[31] See Filmer and Pritchett (2001); Anderson (2008); Mahmud and Prowse (2012); Weldegebriel and Amphune (2017).

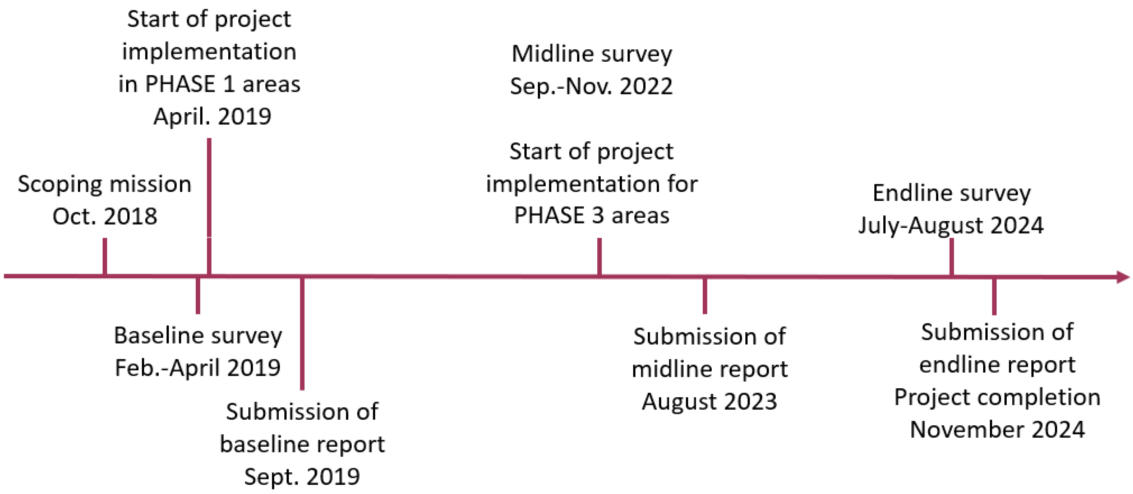
Table II–3. Mitigation evaluation questions and indicators

Activity	Question	Indicator
	EQ11. Do patrolling interventions lead to better enforcement of regulations in the forest protected area?	EQ11.1. Law enforcement
	EQ12. Do patrolling interventions result in a reduction in deforestation?	EQ12.1. Quantity of deforestation
		EQ12.2. Charcoal consumption

Source: LORTA team

36. The IE of the SLEM project comprises three waves of data collection: baseline, conducted from February to May 2019; midline, conducted in September and November 2022; and endline, planned for June and August 2024.[32] Figure II–3 illustrates the timeline of the IE activities in parallel with the project's implementation timeline.

Figure II–3. Timeline of the IE of the SLEM project



Source: LORTA team

[32] These three waves of data collection will allow us to measure the short- and medium-term impacts of SLEM interventions. However, follow-up studies will be needed to test if these impacts are sustained over time.

III. EVALUATION STRATEGY AND DESIGN

A. DESIGN

37. We have developed two complementary IE designs: a cluster randomized phase-in and a Difference-in-Difference (DiD) approach combined with matching. To measure the impact of SLEM adaptation activities, we use (i) an experimental approach to capture the project's short-term impacts at midline and (ii) a quasi-experimental approach for longer-term impacts at endline.[33] This report focuses solely on the first IE design: the clustered randomized phase-in design at midline. The second design will be the focus of the endline evaluation report to be completed by the end of the project.

1. IMPACT EVALUATION DESIGN FOR SLEM MIDLINE IMPACTS: CLUSTER RANDOMIZED PHASE-IN

38. A cluster randomized phase-in is an experimental design that relies on randomizing the order in which each eligible cluster receives the programme activities. All eligible COBAs of the SLEM project receive the interventions through a staged pipeline approach. Thanks to a roll-out of activities in several stages, it was still possible to randomly select the order in which eligible COBA participated in the project. Clusters randomly assigned to a later phase serve as the control group until they start receiving the interventions.

39. The unit of assignment for the SLEM project is the COBA. In order to avoid social conflicts within COBA, we opted for a cluster randomization, with the COBA being the *cluster* of farmers and patrollers that will be randomly allocated into the different phases of the project.[34] This approach is different to simple randomization, where individual farmers and patrollers within COBA are the unit of randomization. An additional advantage of a cluster randomized design is limiting the contamination of the control group. Indeed, we expect some contamination to occur within control group participants, as farmers and patrollers who receive interventions may share new information with individuals who have not participated in the project. Based on information provided during our field visit by project staff, we anticipated interaction and information-sharing with members of other COBA to be rare.

40. For a rigorous IE, the order of phase-in of the eligible units must be determined randomly. According to the law of large numbers, a sufficiently large number of observations is necessary for the process of randomized selection of beneficiary units in the different phases of the programme to produce groups that are similarly effective on average. In other words, if the number of eligible units is large enough, we can assume that the first beneficiary group and groups subsequently phased-in have the same observable and unobservable characteristics on average. Hence, randomization ensures the greatest degree of comparability between initial project beneficiaries and future beneficiaries before the project roll-out.

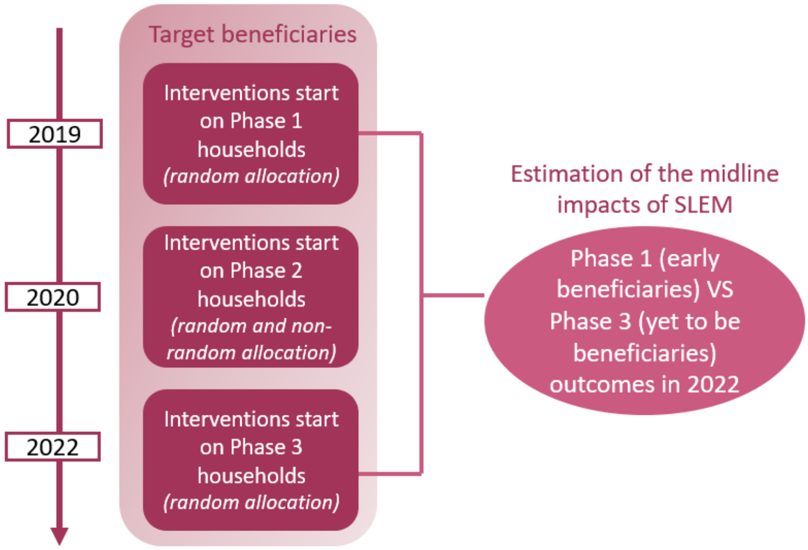
41. Data collection on both groups before the start of the project allows us to verify that observable background characteristics are balanced between the treatment and comparison groups. When the two groups have balanced characteristics, any differences between the two groups that we observe

[33] From late 2022, SLEM implementation has been extended to the households that served as a comparison group for the midline impact evaluation (households assigned to Phase 3). As a result, the endline evaluation has to rely on another comparison group, implying another evaluation design. Combining the experimental and non-experimental approaches in a complementary fashion allows us to increase the timespan the research covers. Both types of comparison groups were interviewed at baseline.
[34] Randomization was completed using a random number generator within pre-determined strata.

after the implementation in the treatment group (and before the phase-in of the control group) will be uniquely attributable to the programme. As an experimental approach, a cluster randomized phase-in is the most rigorous IE method for measuring the impact of the SLEM project.

42. Figure III–1 illustrates the cluster randomized phase-in design used for this midline evaluation. We are implementing the SLEM adaptation activities in three phases. The three stages target a similar number of beneficiaries and were initially evenly spread over three years.[35] For the SLEM midline evaluation, we compared the first phase of beneficiaries (Phase 1) with the last one (Phase 3). There are two main reasons for this. First, the project's outcomes of primary interest, namely food security, vulnerability and deforestation, will likely evolve slowly over time. Hence, comparing Phase 1 with Phase 2 after only one year of project implementation did not seem cost-effective. Instead, focusing on the first and third phases of the roll-out allows us to measure the project's impacts after two-and-a-half years of intervention in Phase 1 areas. Second, some groups were ineligible for randomization and thus excluded from the evaluation. We allocated these groups to the second phase of the project implementation.[36]

Figure III–1. Cluster randomized phase-in design



Source: LORTA team

43. To account for the geographic heterogeneity of the intervention area and the size of the forest covered by the COBA, and following discussions within the project team, we opted for stratified randomization. The stratification comprises three levels: geographic location, the area of forest surface the COBA is responsible for, and the number of COBA members. The geographic location stratification was based on four geographic areas: the northern and the southern regions of COFAV and the eastern and western regions of CAZ. The latter two levels of stratification are determined as

[35] The COVID-19 pandemic caused delays in the project's implementation, postponing the start of Phase 3 from 2021 to 2022.
[36] During discussions with the project team, it appeared that some communities could not receive the programme in the first phase (if they were randomly allocated to be so), because this would conflict with CI or wider interventions. Therefore, these communities had to be excluded from the impact evaluation's samples. It is important to state clearly that all these communities still participated in the second phase of the project without undermining the randomization of other communities between the first and the third phases.

follows: (i) three quantiles of the surface of the forest covered by the COBA, measured in hectares[37] and (ii) two quantiles of the size of the COBA, measured by the estimated number of group members. The stratification ensures that the proportion of these regions and groups is similar across the phases. Two advantages arise from this approach. First, by gaining control of the sample's composition, we improve the precision in estimating the programme's impacts and achieve more balance on important characteristics between treatment and control COBA in the various phases. Second, it ensures the representativity of these subgroups in each phase. From the pool of COBAs eligible for randomization, we randomly assigned 51 COBAs to the programme's first phase and 50 COBAs to the third phase.

2. Heterogeneous effects

44. CAZ and COFAV areas differ in geographic location, population and biodiversity. As such, the impacts of SLEM adaptation activities will also be analysed separately by CAZ and COFAV locations to examine whether the project's ability to affect households' livelihoods differs according to the location of the residence. To explore gender differences, the impacts will also be estimated separately by the gender of the household head. Finally, two other dimensions of heterogeneity will also be considered: (i) initial level of vulnerability and (ii) distance to forests. Each of these variables will interact with the treatment dummy to assess whether the impacts of SLEM adaptation activities differ with larger values of vulnerability and distance to forests. Households with differing levels of vulnerability and distance to forests may face different constraints and opportunities, limiting or enhancing the project's impacts. It is important to note that the sample size was designed to detect impacts in the whole sample. Hence, every subgroup analysis will suffer from a reduction in statistical power.

3. Assumptions and limitations

45. A cluster randomized phase-in design crucially assumes that with a sufficiently large number of units – individual COBAs in this case – COBAs randomly assigned to Phase 1 are, on average, similar to those assigned to Phase 3 on both pre-treatment observable and unobservable characteristics. If the randomization ensures COBAs assigned to the various phases are, on average, similar, the causal effects of the SLEM adaptation activities can be identified without any selection bias. A clustered randomized phase-in design also guarantees bias-free estimation of the causal effects of the SLEM adaptation activities even in cases where treatment and control units differ on at least one observable characteristic, a result that could occur by chance (Mutz, Pemantle and Pham, 2019). A standard approach to assess the similarity of treatment and comparison groups involves performing t-tests of the statistical significance of differences in average characteristics between the two groups at baseline. If statistically significant differences in average characteristics are identified, the robustness of the results is assessed by estimating regression specifications, with and without the unbalanced characteristics as covariates. Details on the exact regression specifications that will be estimated are further outlined below.

46. One potential risk in a cluster randomized phase design is "anticipation effects". Anticipation effects occur when COBAs in the comparison group randomly allocated to receive treatment in Phase 3 of the programme anticipate receiving programme benefits in the future and consequently change their behaviour before they participate in the programme. Anticipation effects imply that the impact estimates that the programme may uncover may represent a lower bound of the programme's

[37] The surface covered by a COBA is independent from the number of patrollers, set to four individuals, which likely affects the mitigation activities.

potential impact in the absence of these effects. One way to avoid anticipation effects within a cluster randomized phase-in design would be not informing COBAs randomized to receive the SLEM adaptation activities in Phase 3 that they will eventually receive the activities. However, the project team has omitted this option to avoid social discontent and a feeling of unfairness within the target area. Furthermore, not informing Phase 3 COBAs would have been undesirable as it would have prevented the IE from leveraging the cluster randomized phase-in design as a strategy to limit attrition.

47. As for other IE designs, contamination of the control group is a significant risk. In the case of this evaluation, contamination would occur if Phase 3 target beneficiaries directly or indirectly benefited from the interventions in Phase 1 COBA or if interventions in Phase 3 communities started before the midline survey. There is some evidence of contamination due to the delays in implementing the midline survey. Indeed, some SLEM interventions in Phase 3 started in August 2022, while the data collection took place between late September and November 2022 (see section E). As mentioned above, the SLEM project's impact estimates may represent a lower bound of the programme's potential impact in the absence of these effects.

48. Another potential risk in the context of randomized designs is "attrition" explicitly related to clustered phase-in designs. Attrition is essentially a situation in which data on specific observations is missing. It usually occurs when households in treatment and/or comparison COBAs included in the baseline cannot be followed up for reinterview at midline or endline because they have moved away or refuse to participate in the follow-up rounds of data collection. Thus, a high attrition rate severely reduces the number of households available for reinterview in the follow-up rounds and, by implication, reduces the study power to detect a given effect size as outlined in the power calculations (see section C.). The effects of attrition are particularly concerning when "differential attrition" occurs. Differential attrition occurs when the rates of attrition (and by extension the characteristics of those who drop from the sample) vary across treatment and control households. This can undermine the randomization of units and reintroduce selection bias into the sample. Differential attrition has implications for how treatment effects can be estimated and interpreted and the implications of differential attrition for this study are further discussed below.

49. An additional potential risk is "imperfect compliance" with the treatment assignment. Imperfect compliance refers to a situation in which some households in treatment COBAs do not receive the treatment when they should and/or those in comparison COBAs end up receiving it when they should not. Because identification of the SLEM programme's causal effects relies on differential exposure of treatment and comparison COBAs to the programme, imperfect compliance may reduce our ability to detect the programme's impacts. Because a cluster randomized phase-in design with treatment assigned at the COBA level limits the extent to which households in treatment and comparison COBAs interact, it therefore includes a built-in mechanism to avoid exposure of the comparison group to the SLEM programme. According to the SLEM project team, a small number of households decided to leave the COBAs or refused the project activities. Self-reported information on the project benefits and monitoring data will be used to identify those cases. The occurrence of imperfect compliance has implications for the analysis and interpretation of the findings of this study. Its implications are further discussed below.

B. STRATEGY

1. DESCRIPTION OF THE UNITS FOR DECISION-MAKING, INTERVENTION AND ANALYSIS

50. The SLEM project relies on a community-based approach through the close collaboration between the project team and local communities, which were consulted to best adapt the project activities to each community's needs and interests. Most of the SLEM activities were implemented at the community level through COBAs. In this report, we focus on estimating the midline SLEM impacts on households, our unit of analysis of this midline IE.

2. IDENTIFICATION STRATEGY AND EMPIRICAL STRATEGY

51. As noted above, we used a cluster randomized phase-in design to identify the short-term causal effects of SLEM activities on the key outcomes of interest, notably on food security and vulnerability. The causal effects were identified by comparing the average outcomes in treatment COBAs randomly allocated to Phase 1 with average outcomes in comparison COBAs randomly allocated to Phase 3. As COBA members may choose not to participate in the SLEM activities, the estimated impacts corresponded to ITT effects. ITT are the impacts of having randomly assigned COBAs into Phase 1, irrespective of the actual reception of SLEM benefits.

$$\beta = \overline{y_{p1}} - \overline{y_{p3}} \tag{1}$$

52. This is shown in equation (1) above, where β captures the causal effect of being randomly assigned to receive the SLEM adaptation activities on the outcomes of interest. In this equation, this causal effect is obtained by subtracting the average outcome in treatment COBAs, $\overline{y_{p1}}$ and the average outcome of comparison COBAs, $\overline{y_{p3}}$.

$$y_{ji} = \alpha + \beta T_i + Strat_i + \varepsilon_{ji} \tag{2}$$

where $Strat_i = N\_COFAV_i + S\_COFAV_i + E\_CAZ_i + S1_i + S2_i + N1_i$

53. Instead of equation (1), β was formally estimated within a linear regression framework, with the most basic specification shown in equation (2) above. In this equation, y_{ji} represents each respective outcome of interest in household j located in COBA i, while α is a constant representing the average outcome in the comparison group. In this case, β also represents the difference in the average outcome of interest between treatment and comparison and will be obtained as the coefficient of a treatment dummy T_i, which takes the value 1 if household j is located in a Phase 1 COBA and 0 otherwise. Given that β captured the causal effects of being randomly assigned to the SLEM adaptation activities in Phase 1, it captured the ITT estimate of the effects of these activities. In order to account for the stratification in the randomization, various sets of stratification dummies, represented by $Strat_i$ were also included in this specification.

54. Specifically, N_COFAV_i, S_COFAV_i and E_CAZ_i equalled 1 if COBA i was located in either the north or the southern regions of COFAV or the eastern regions of CAZ, respectively, and 0 otherwise. COBAs in the western regions of CAZ served as the omitted reference category. Additionally, stratification dummies $S1_i$ and $S2_i$ equalled 1 if COBA i was located in the largest two categories of the forest surface area that the COBA was responsible for and 0 otherwise. For this stratification, the forest surface area for which the COBA was responsible was divided into

three categories of equal size based on its distribution[38], with stratification dummies for the first and second largest categories included in the above specification and the smallest category being the omitted reference category. Similarly, the number of COBA members was also divided into two categories of equal size based on its distribution[39]. Thus, a stratification dummy $N1_i$ equalled 1 if COBA i was located in the largest category $N1_i$ and 0 otherwise was also included, with the smaller category as the omitted reference category. ε_{ji} in equation (2) represents the idiosyncratic error term. Standard errors in this specification were clustered at the COBA level to account for the fact that, since treatment was assigned at the COBA level, observations within each COBA were likely to be similar and therefore could not be viewed as independent. Instead, they formed a single cluster of correlated individual observations.

$$y_{ji} = \alpha + \beta T_i + \lambda_j X_{ji} + Strat_i + \varepsilon_{ji} \quad (3)$$

55. While estimating equation (2) within the context of a cluster randomized phase-in design guaranted that β could be estimated free of any selection bias, the precision of estimates of this parameter could be increased by including control variables highly correlated with each outcome of interest. Such a regression specification is shown in equation (3) above, where X_{ji} represents characteristics of household j located in COBA i that was included as control variables in the regression.

56. X_{ji} are selected based on their correlation with the outcome of interest. Good candidates include baseline information on the gender of the household head, his/her age, ethnicity, level of education and place of residence (i.e. municipality), household composition (i.e. number of adults and number of children), land ownership, distance to the Fokontany Center (Village Centre), distance to the closest forest, level of food security and vulnerability, strata fixed effects and the baseline value of the outcome of interest. Furthermore, we include variables that showed an imbalance at baseline[40] and those highlighted in the attrition analysis.

57. Estimating the causal effects of the SLEM activities was based on a representative sample of households with at least one member taking part in a COBA in CAZ and COFAV and not the entire populations in these areas. To ensure the estimates based on this sample are representative of the target population in CAZ and COFAV (i.e. Phase 1 and Phase 3 COBA members) from which they are sampled, sampling weights equivalent to the inverse probability that an observation in the target population is sampled, have been included in the analysis.

3. ROBUSTNESS CHECKS

58. As noted in the baseline report (Independent Evaluation Unit, 2020), while treatment COBAs randomized to Phase 1 and comparison COBAs randomized to Phase 3 were broadly similar in terms of sociodemographic characteristics, several differences in other observable characteristics were noted at baseline.[41] These include differences in the distribution of some types of livestock (ducks and animal breeding), forest products (coffee and leaves for ripening fruits), and strategies implemented to reduce sensitivity to climate-related hazards (such as using rice during a drought in the off season). Differences were also found for multi-cropping and improving or creating grain storage among the top three strategies used by households. In the case of livestock, differences were

[38] The first category includes forest surface areas, ranging from (i) 40 to 936 hectares, (ii) 1000 to 2500 and (iii) 2506 to 11108.
[39] The first category includes COBA with 15 to 70 members, while the second includes 73 to 500 members.
[40] These variables include collecting fruits/plants as a main source of livelihoods, duck ownership, coffee cultivation, practicing resistance crop, multi-cropping or pest management, and having reported a decrease in forested area, all obtained from the baseline survey.
[41] These differences were revealed by t-tests conducted on the baseline characteristics as outlined in the baseline report (Independent Evaluation Unit, 2020).

found in animal production when there was a frost. In contrast, differences were found in forest and tree products in reducing forest degradation during drought. Regarding the severity of shocks, differences were found concerning the changes that negatively and severely affected livelihoods in the last 12 months (e.g. flood intensity) and household fruit consumption. Thus, specification (3) permits us to assess our estimates' robustness by directly controlling for these observable differences between the Phase 1 treatment group and the Phase 3 comparison group in the analysis.

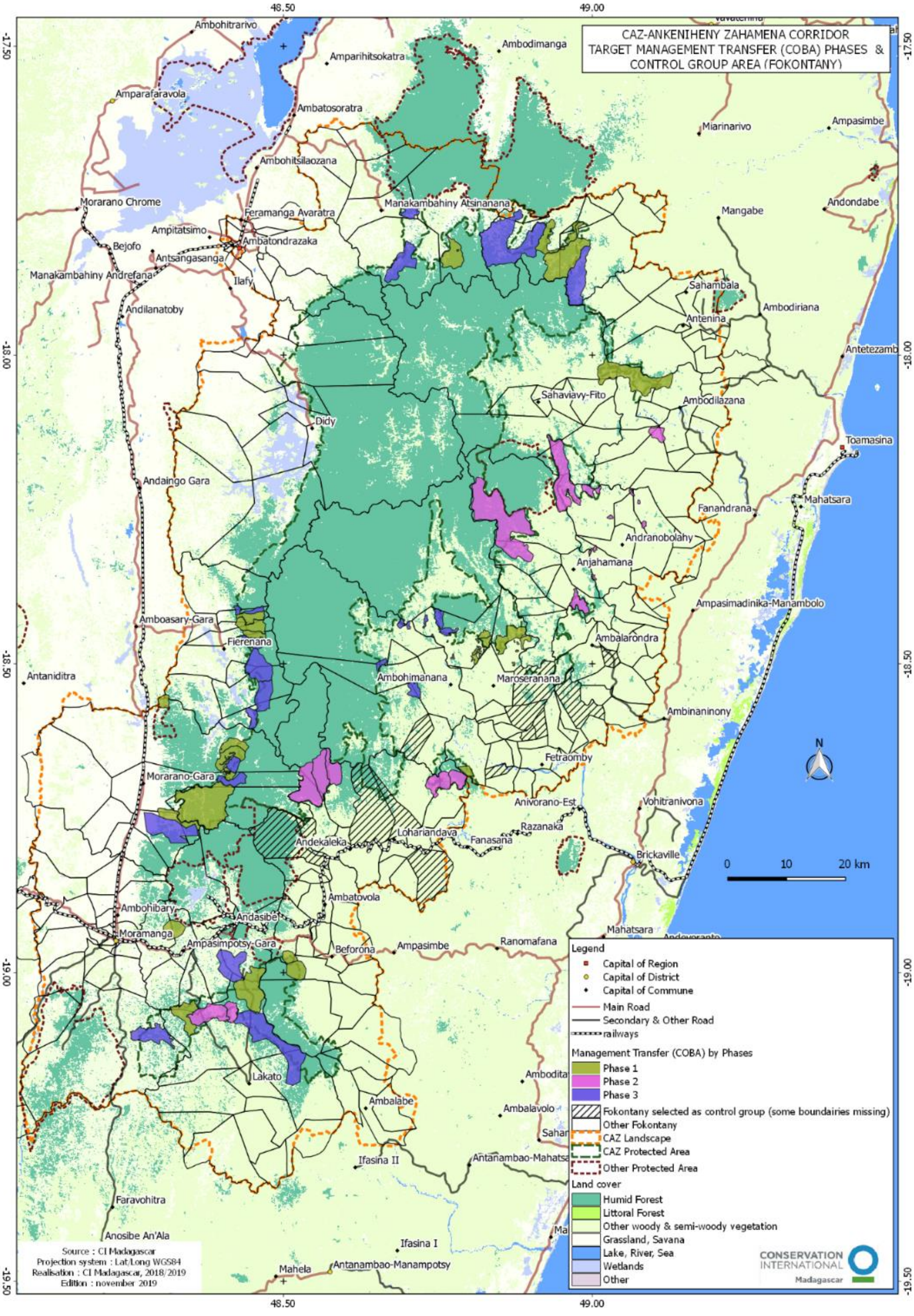
59. In the event of substantial non-compliance with treatment assignment in the treatment and/or comparison groups, an instrumental variable (IV) analysis will be conducted. This is because actual treatment take-up, represented by T_i in equations (2) and (3) above can no longer be considered randomly assigned. In the IV analysis, the random assignment to treatment (to Phase 1) will first be regressed on actual treatment take-up T_i and fitted values from this regression will then be regressed on the outcomes of interest as per equations (2) and (3). In this way, randomized assignment to treatment will be used as an instrument for treatment actually taken up. This implies that the randomized assignment to treatment impacts the outcomes of interest only through its causal impact on actual treatment take-up, T_i. Thus, exploiting this relationship allows us to estimate the causal effects of T_i on the outcomes of interest. Estimates obtained this way will then be interpreted as Local Average Treatment Effects (LATE) on the compliers. This refers to the causal effects of the SLEM adaptation activities on those households who actually receive treatment because they were randomly assigned to Phase 1.

60. The availability of data at two different time periods (baseline and endline) and two separate groups (treatment COBAs randomized to Phase 1 and comparison COBAs randomized to Phase 3) will allow us to test the robustness of our results to different identifying assumptions. Specifically, we will be able to also utilize a random effects regression specification within a DiD design, which relies on the parallel trends assumption. Estimating this specification as a robustness check will also permit us to explicitly account for any time-invariant unobservable differences between the two groups and to assess if our results remain similar to those obtained based on the cluster randomized phase-in design.

4. SAMPLING STRATEGY AND SAMPLE SIZE

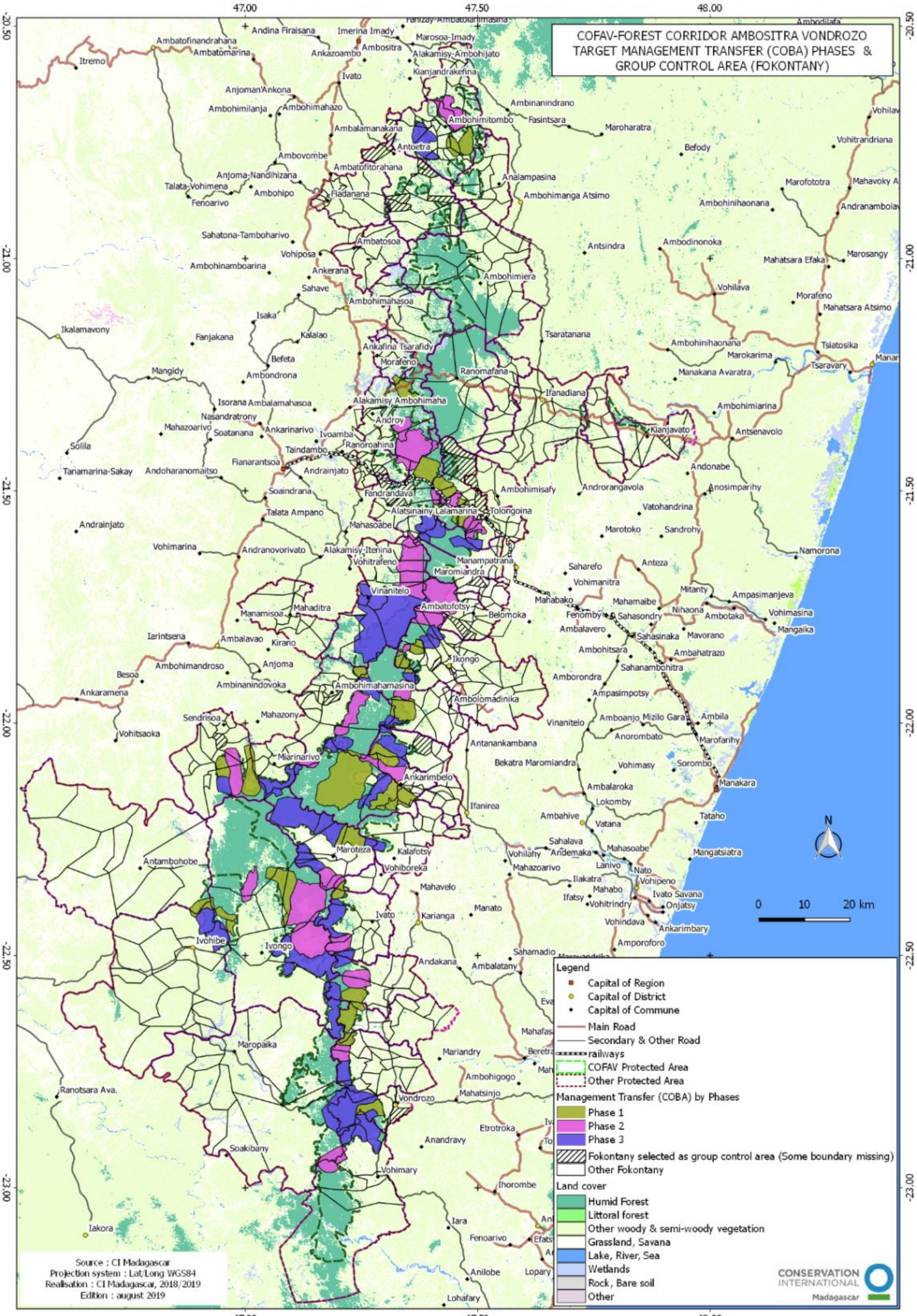
61. As explained above, to account for the geographic heterogeneity of the intervention area and the size of the forest covered by COBAs, the LORTA team opted for a stratified randomization for the sample selection. The stratification ensures that the proportion of each of these regions and groups is similar across the phases of project implementation. Two advantages arise in doing so. First, gaining control of the sample's composition improves the estimation of the project’s impacts. Second, it ensures that subgroups are represented in each phase. To reiterate, from the pool of COBAs eligible for randomization, 51 COBAs were randomly assigned to the first phase and 50 COBAs to the programme's third phase (see Figure III–2 and Figure III–3).

Figure III–2. Map of areas selected for Phase 1, Phase 3 and the outside control group in CAZ



Source: Conservation International Madagascar

Figure III–3. Map of areas selected for Phase 1, Phase 3 and the outside control group in COFAV



Source: Conservation International Madagascar

62. The number of households interviewed in the survey was determined at baseline by power calculations and the project's limited budget. The LORTA team performed these power calculations to estimate the Minimum Detectable Effect Size (MDES) that could be detected by the household survey considering the project's constraints. These constraints consist of the number of clusters in which the project will be implemented during each phase (50 COBAs) and the budget allocated for data collection.

63. We are interested in two bilateral comparisons. Firstly, between the first beneficiary group (COBA members from Phase 1) and the comparison group within the area of intervention (COBA members from Phase 3) and, secondly, between the first beneficiary group and a comparison group outside the areas covered by COBAs (the DiD with the matching control group). Therefore, the MDES needed to be estimated separately for each comparison. Considering an equal allocation ratio between these three groups, the maximal sample size within budget constraints for each comparison was equal to 1652 households.[42]

64. The MDES was calculated with the following formula:

$$MDES = (t_{1-\kappa} + t_{\alpha})\sqrt{\frac{1}{P(1-P)}}\sqrt{1+\rho(l-1)}\sqrt{\frac{\sigma^2}{N}}\sqrt{1-R^2} \quad (4)$$

where $t_{1-\kappa}$ and t_{α} are t-statistics representing the required power and level of statistical significance, P represents the proportion in one of the two compared groups (allocation ratio), ρ is the intra-cluster correlation (ICC), l is the number of individuals per cluster, σ^2 is the variance of the outcome of interest within our population, N is the total sample size and R^2 represents the extent to which baseline characteristics predict the endline outcome.

65. The MDES was estimated for a power of 80 per cent and a level of statistical significance of 5 per cent. Since we considered a clustered design, we accounted for the similarity of members within the same COBA. This similarity is measured by the ICC, which compares the variance in outcomes of interest (for this calculation, food insecurity) within and between clusters. When outcomes tend to be more similar between members of the same COBA and differences exist between COBAs, it reduces our ability to observe sufficient variability in household responses to interventions. As a result, the sample size required to detect a significant difference between the treated and the control group increases. Because there was no quantitative data on food security and vulnerability at the COBA level before the baseline household survey, the evaluation team followed the literature's approach and considered four different values of ICC: 0.05, 0.10, 0.15 and 0.20.

66. To estimate the variance of outcomes of interest, the evaluation team used the Afrobarometer 2017, a nationally representative household survey. This survey contains information on one proxy of food insecurity, one of the main impact indicators of the SLEM project. The evaluation team considered an indicator equal to 1 if the interviewed individual reported that s/he or a member of her/his household often or always lacked food during the last 12 months and 0 otherwise. According to food insecurity information from Afrobarometer, 55 per cent of individuals residing in the regions that include the COFAV and CAZ landscapes are food insecure. The standard deviation is equal to 0.50.

67. Table III–1 shows the results of power calculations assuming different values of ICC.[43] According to the most conservative scenario, the change in food insecurity brought by the project will need to be as large as 25 per cent to be identified in bilateral comparisons with 826 observations per group.

[42] Note that in a case where the number of clusters cannot be increased, an equal ratio is optimal. Indeed, although the treated group will be used in two types of bilateral comparisons, the benefits obtained from increasing the size of these bilateral samples is counteracted by the increase in the average cluster size.
[43] Power calculations were also performed for alternative number of clusters. The smallest MDES is achieved when the greatest number of clusters is considered.

As we are considering three groups (Phase 1 COBAs, Phase 3 COBAs and the outside comparison group), this gives us a total sample of 2478 households to be interviewed at baseline. In other words, smaller changes may be interpreted as an absence of project impacts on this indicator. However, according to documented impacts of previous agricultural input innovation programmes in Africa, this minimum effect size may be a reasonable lower bound of the expected impacts of the SLEM programme on food security (for instance, see Stewart and others, 2015).

Table III–1. Power calculations

Indicator	ICC	# of clusters per group (COBA)	Total target sample at baseline	R2	Size of clusters # of households	MDES (in % points)	% change in food security
Food insecurity	20%	50	2478	30%	16,52	0,116	21,2%
Food insecurity	20%	50	2478	0%	16,52	0,139	25,3%
Food insecurity	15%	50	2478	30%	16,52	0,105	19,1%
Food insecurity	15%	50	2478	0%	16,52	0,125	22,8%
Food insecurity	10%	50	2478	30%	16,52	0,092	16,7%
Food insecurity	10%	50	2478	0%	16,52	0,110	19,9%
Food insecurity	5%	50	2478	30%	16,52	0,077	13,9%
Food insecurity	5%	50	2478	0%	16,52	0,091	16,6%

Source: LORTA team

68. The target number of 2,478 at baseline (i.e. 826 per group) was increased by 10 per cent to account for potential attrition. As such, a total sample of 2,730 households were interviewed at baseline. An equal number of households per cluster (i.e. COBA for the project's intervention area and fokontany for the outside comparison group) was randomly selected from lists of COBA members and fokontany inhabitants. Among the latter, households not involved in crop farming were excluded from the survey and replaced by the next household randomly selected in the same fokontany. The baseline sample comprised 1,822 households from the SLEM's intervention area (966 households from Phase 1 and 846 from Phase 3) and 908 households outside SLEM's intervention area, giving us a total of 2,730 households. We now focus solely on the clustered phase-in design that examines details of the second evaluation design comparing Phase 1 with the households outside SLEM's intervention area will be reported in the endline report.

C. Attrition

1. Background: Why conduct an attrition analysis?

69. As mentioned above, attrition is a potential risk to our evaluation design. Attrition is essentially a situation in which data on specific observations is missing. It usually occurs when households in treatment and/or comparison COBAs included in the baseline cannot be followed up for reinterview at midline or endline either because they have moved away or refuse to participate in the data collection's follow-up rounds. A high attrition rate severely reduces the number of households available for reinterview in the follow-up rounds and, by implication, reduces the study power to detect a given effect size as outlined in the power calculations. Furthermore, it affects how accurately the sample represents the target population. If households not interviewed during the

midline survey differ from those being followed up, the estimated impacts of the project may not be valid for the population that is no longer part of the sample.

70. The effects of attrition are particularly concerning when differential attrition occurs. Differential attrition refers to a situation in which the rates of attrition and the characteristics of those who cannot be followed up between treatment and control differ, particularly with reference to those who remain in the study. This type of attrition may imply that selection bias, previously avoided through randomization, is reintroduced into the sample. Differential attrition has implications for estimating and interpreting treatment effects.

2. Results of the attrition analysis

71. The majority of households interviewed at baseline could be interviewed again at midline, with an attrition rate of 9.2 per cent (168 observations). This rate is lower than the anticipated buffer of 10 per cent during the study's design.[44] Hence, the loss in sample size does not reduce the study power. The design offered a built-in mechanism to help maximize retention and limit attrition. This is because those in Phase 3 are that they will eventually participate and thus have an incentive to remain in the programme.

72. As can be seen in Table III–2, the two main reasons why these households could not be surveyed at midline were migration (33.3 per cent) and not being available at the time of the survey due to a family event, family visit, travel or hospitalization (32.7 per cent). The reasons vary slightly between Phase 1 and Phase 3 households. While around one-third of households were missing because of migration in both groups, temporary unavailability was more important among Phase 3 households (40.8 per cent) than among Phase 1 households (26.8 per cent). In contrast, the death of the target respondent, the household not being located, and two target respondents forming a new household were more frequent among Phase 1 than Phase 3 households.

Table III–2. Reason for households not being interviewed at midline

	Phase 1	Phase 3	Total
No consent to survey: left the COBA	4 (4.1%)	0 (0.0%)	4 (3.1%)
No consent to survey: still a member of the COBA	1 (1.0%)	1 (1.4%)	2 (1.2%)
Left the COBA	4 (4.1%)	4 (5.6%)	8 (4.8%)
Death of person and the family representative is under 18/no family available/no family	10 (10.3%)	3 (4.2%)	13 (7.7%)
Death of person and non-consent of the family member to participate in the survey	2 (2.1%)	1 (1.4%)	3 (1.2%)
Migration	31 (32.0%)	25 (35.2%)	56 (33.3%)
Household not located	12 (12.4%)	3 (4.2%)	15 (8.9%)
Not available/Absent during the interviewers' visit (e.g. family event, family visit, travel, hospitalized)	26 (26.8%)	29 (40.8%)	55 (32.7%)
In the same household/Two different households at the beginning and became one household (married)	7 (7.2%)	3 (4.2%)	10 (6.0%)
Never been a member of the COBA	0 (0.0%)	2 (2.8%)	2 (1.2%)

[44] As per convention in the literature, a rate of attrition of 5% or less is considered low, while a rate of attrition of 20% or more will be considered high across the whole sample (Schulz and Grimes, 2002).

	PHASE 1	PHASE 3	TOTAL
Total	**97 (100%)**	**71 (100%)**	**168 (100%)**

Source: LORTA team

73. Attrition analysis was conducted by calculating the attrition rate for the sample as a whole and by treatment status. This is important as the characteristics of those households that drop from the treatment and control groups may vary systematically.

74. We explore the existence of differential attrition by running a probit regression for the whole sample interviewed at baseline and by implementation phase. The dependent variable equals 1 if a household was not interviewed at midline and 0 otherwise. The independent variables are taken from the baseline survey and, as is widespread in the literature, consist of key sociodemographic characteristics of the baseline household head, household characteristics and livelihood indicators. Results are displayed in Table III–3. Our final regressions include 1,803 out of 1,822 households interviewed at baseline because of missing values on some independent variables.[45]

Table III–3. Attrition analysis at midline

VARIABLES	ATTRITION IN THE WHOLE SAMPLE (1)	ATTRITION WITHIN PHASE 1 (2)	ATTRITION WITHIN PHASE 3 (3)
Female household head	-0.16	-0.12	-0.18
	(0.15)	(0.19)	(0.23)
Ethnicity (ref. Other)			
Ethnicity = 1, Betsileo	-0.21	-0.78***	0.63
	(0.30)	(0.30)	(0.38)
Ethnicity = 2, Betsimisaraka	0.20	0.13	0.37
	(0.16)	(0.23)	(0.27)
Ethnicity = 3, Bezanozano	-0.21	-0.16	-0.23
	(0.20)	(0.23)	(0.31)
Ethnicity = 4, Tanala	0.10	-0.04	0.50
	(0.25)	(0.24)	(0.33)
Age of the household head	0.00	0.01	-0.00
	(0.00)	(0.01)	(0.01)
Education (ref. None)			
Highest education level in the household = 2, Primary school	-0.18	-0.30	0.04
	(0.14)	(0.21)	(0.22)
Highest education level in the household = 3, Above primary	-0.13	-0.28	0.19
	(0.18)	(0.24)	(0.25)
Number of adults at baseline	-0.01	0.01	-0.02
	(0.03)	(0.04)	(0.05)
Number of children at baseline	-0.03	-0.05*	0.02
	(0.02)	(0.03)	(0.03)
Food security index (ref. Food secure)			
Food security index = 2, Marginally food secure	-0.29**	-0.07	-0.43***
	(0.11)	(0.16)	(0.14)

[45] Notably, information on baseline land ownership is only available for 1809 households.

VARIABLES	ATTRITION IN THE WHOLE SAMPLE (1)	ATTRITION WITHIN PHASE 1 (2)	ATTRITION WITHIN PHASE 3 (3)
Food security index = 3, Moderately Insecure	-0.34***	-0.07	-0.53**
	(0.13)	(0.19)	(0.22)
Food security index = 4, Severely Insecure	-0.58**	-0.82**	-0.34
	(0.26)	(0.35)	(0.39)
Land ownership (in log)	-0.22***	-0.17**	-0.27**
	(0.08)	(0.09)	(0.11)
Total expenditures at baseline (in log)	-0.04	-0.06	-0.04
	(0.05)	(0.06)	(0.09)
Residence in CAZ (ref. residence in COFAV)	0.23	0.03	0.97***
	(0.24)	(0.29)	(0.37)
Distance to fokontany center (in log)	0.03	-0.04	0.12
	(0.05)	(0.05)	(0.08)
Distance to closest forest (in log)	0.01	-0.12*	0.20***
	(0.06)	(0.06)	(0.07)
Observations	1,803	903	900

Source: LORTA team
Note: Marginal effects from probit regressions.
Attrition refers to not having participated in the midline survey.
All independent variables are obtained from the baseline survey.
Standard errors clustered at the COBA level.
Sampling weights are used.
*, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

75. Overall, greater food insecurity at baseline significantly decreases the likelihood of households dropping from the sample. In other words, the more food insecure the household at baseline, the lower the likelihood of departure from the sample or not giving consent for the midline questionnaire. Specifically, being marginally food insecure, moderately food insecure, or severely food insecure is correlated with a decrease in the probability of dropping from the sample (or, in other words, increases the likelihood of participating in the midline survey) by 29, 34 and 58 percentage points, respectively. It can be interpreted that more food insecure households see future benefits from the programme and have been more likely to remain within the sample.
76. The logged land variable suggests that households with more land were more likely to participate in the midline survey. A 10 per cent increase in the size of land ownership at baseline is correlated with an increase in the probability of participating in the midline survey by 2.2 percentage points. It can be interpreted that these households believe they are likely to improve agricultural production in the future due to the emphasis on agricultural inputs from the project.
77. A key consideration for the IE estimates is differential attrition in Phase 1 and Phase 3 households. This is corrected for in the estimations by including relevant covariates.
78. For Phase 1 households, a number of variables decrease the probability of dropping from the sample: being a household from the Betsileo ethnic group, being severely food insecure or having more land. We also find two variables statistically significant at the 10 per cent level: households

further from the closest forest and households with more children are less likely to drop from the sample.[46]

79. For Phase 3 households, being marginally or moderately food insecure or having more land decreased the probability of dropping from the sample. Moreover, being a resident in the CAZ decreased the likelihood of taking part in the midline. In addition, distance to the closest forest was rated as significant this time at the 1 per cent level because households further from the closest forest were less likely to participate in the midline survey. All the variables that are significantly associated with the probability of attrition have been included in version 3 and version 4 of the specifications of our three forms of analysis: a main specification, DiD with random effects and LATE estimates (see section IV.B, which describes all four specifications and forms of analysis).

D. Data and quality assurance

80. As outlined above, the IE of the SLEM project comprises three waves of data collection: baseline, started in February 2019 for three months; midline, conducted for about 50 days in September and November 2022; and endline, planned for June to August 2024. The baseline data collection was conducted in person using paper instruments. Overall, 2,730 household surveys were collected (1,094 in CAZ and 1,636 in COFAV).

81. The midline questionnaire was developed from the baseline instrument and updated by adding questions, including about COVID-19, participation in project activities and perceptions about the project. A total of 37 enumerators and supervisors, including both men and women, oversaw data collection. In total, 1,822 households were targeted for the survey for the midline (732 for CAZ and 1,090 for COFAV). The questionnaire has 12 sections (see Appendix 5). For midline, we conducted computer-assisted personal interviews (CAPI), a face-to-face data collection method in which the enumerators use a mobile phone or another electronic device (e.g. a tablet) to record information. The questionnaire was translated into Malagasy, and all interviews were conducted in this language.

Table III–4. Households targeted at midline

	CAZ	COFAV	Total
Phase 1	406	560	966
Phase 3	326	530	856
Total	732	1,090	1,822

Source: LORTA team
Note: Three baseline household interviews were duplicated (same farmer respondent but recorded at baseline under different names) in the listing of farmer households to be tracked at endline, hence the target sample size was 1,799 as opposed to 1,802. Attrition rates disaggregated by source were not recorded during the endline data collection.

82. The technical specifications required were a mobile phone or tablet with at least Android 9 to support Kobo toolbox free software, 2GB RAM and available memory to store the data. Enumerators used solar panels and their power banks to ensure they had enough power to collect the data. As many places lacked electricity or power, these requirements were essential.

[46] In both cases, these groups are likely to require additional support from the project to improve their climate resilience. Also, these households may have a greater need for support from the project and were thus less likely to drop from the sample.

83. Enumerators received training over 10 days on how to use the Kobo toolbox on their smartphones and could understand the questionnaire on their own. During this training session, the questionnaire was tested with about 17 households that are not beneficiaries of the project but have similar characteristics. Any necessary modifications were made during the training. The questionnaire was verified and updated. Enumerators received a training manual and a survey protocol to guide them during the survey.

84. The data quality process followed four levels. All levels were supervised by CI Madagascar staff. The first level was performed directly during the interviews by enumerators**.** The second level of control was performed by chief enumerators, who checked that the implementing enumerators fully and accurately filled out the questionnaire. In particular, they checked whether there were missing or unclear responses. The chief enumerators also checked that the respondents' names were reported correctly. Two consultants and CI's monitoring and evaluation manager performed a third level of control in Antananarivo. Data calculation was verified, and calls with enumerators/chief enumerators were organized for clarification or additional elements. Finally, during the fourth level, monitoring and evaluation staff checked that the fokontany, commune, region and households coding was accurate and highlighted irregularities in the responses. SPSS software was used to clean the data set and highlight inconsistencies in the responses.

E. CHALLENGES ENCOUNTERED WITH THE RESEARCH DESIGN

85. Several challenges were encountered during the implementation of the survey. At the technical level, a number of enumerators withdrew due to family reasons. As it was the first time we implemented computer-assisted personal interviews using solar panels in these remote areas, we faced some technical challenges. In a number of locations, it was hard to find guides to accompany enumerators due to a high level of insecurity in particular areas. In the more remote areas, phone and tablet connectivity was inadequate, preventing enumerators from sending collected data on time. The Kobo questionnaire included a section where enumerators and chief enumerators were invited to complete information when they encountered any challenges when locating or interviewing a household.

86. The following paragraphs outline broader challenges encountered during the midline survey. In addition, it summarizes how these challenges were addressed.

87. *Challenges with accessing households*: Some households did not want to respond to the survey, while others could not be reached. There were various reasons why households were not surveyed within the midline survey. These included death, being unreachable, migration and non-membership of COBA.[47] Some names were similar within the COBA, and cross-checking household eligibility was time-consuming. To address these challenges, the survey team adopted a series of strategies. Regarding nonresponses, the survey team noted this, as stated in the survey protocol. Additionally, the online monitoring sheet was completed. For households that could not be reached by the survey team, we collaborated with local authorities and our local partners to improve access to households to be surveyed. The increase in transportation fares also posed a challenge to the survey team. The issue of increased transportation fares was solved through effective communication and negotiation with guides.

[47] The endline survey will aim to interview COBA members to understand if and how project effectiveness is related to their internal capacity.

88. *Confidentiality:* The survey team encountered local people who did not want to guide enumerators due to illegal activities in the area. The team addressed these issues through negotiation and communication with local communities, assuring them we would not report any activities.

89. *Gatekeepers:* On a few occasions, it was challenging for the survey team to work with gatekeepers to guide them to respondent households. On other occasions, senior figures within local authorities were also unavailable for an initial courtesy call. To solve these challenges, the team asked for help from other people in the fokontany. In the case of the unavailability of senior figures, the survey team changed the itinerary to ensure local authorities were fully briefed on the survey.

90. *Change in personnel:* The team encountered a challenge when two contracted enumerators withdrew due to family reasons. To address this issue, some team itineraries were updated and extended.

91. *Local security:* There were security issues in some areas. To address this, enumerators were accompanied by local people as guides and received the support of local authorities.

92. *Cultural events:* Cultural and social events (e.g. funerals) affected the implementation of the survey. In such instances, the team changed locations temporarily and returned when people were available.

93. *Connectivity:* As explained above, the team faced challenges accessing electricity and the Internet. The survey team used desktop cables and portable power banks. When poor Internet connectivity prevented enumerators from sending data, the team postponed transmitting the data until finding a reliable connection point.

94. *Broader challenges and solutions:* Additional challenges included ensuring the impact of cyclone Ana did not cause insurmountable problems, checking inconsistencies in some of the data sent by enumerators, and adding one household not included in the list of households to be surveyed.

F. SOFTWARE AND CODE

95. We used the Kobo toolbox for the midline survey, whereas we used a paper version of the questionnaire during baseline in 2019. At baseline, we used Stata, SPSS and Excel to do all the randomization work and conduct balance tests, but during midline, both SPSS and Stata were used. A detailed data book has been provided in the appendices. At baseline, we coded randomization and statistical analysis using Stata. Data, syntaxes and do-files have been transferred for secure storage at the IEU. Table III–5 summarizes the information technology used during the survey.

Table III–5. Information technology used during the survey

SOFTWARE	PURPOSE	PROJECT OBJECTS DERIVED
Stata	Randomization	Assignment of COBA into three phases
Excel	Descriptive Analysis	Descriptive statistics for baseline report
Stata	Balance tests	Assessing similarity at baseline
Kobo Tool Box	Data collection	Midline survey instrument
Smartphone Android devices	Data collection from the field	Datasheet filled in for each household
Excel	Data Control	Data control and review from the field
SPSS	Data preparation and descriptive statistics	Data cleaning, indicators creation, descriptive statistics and initial mean difference tests
Stata	Causal analysis	Estimation of the midline project impacts

SOFTWARE	PURPOSE	PROJECT OBJECTS DERIVED
ARC GIS	Spatial analysis	Matching of survey units to administrative units

Source: LORTA team

G. ETHICS

96. The project team respected ethical standards by following CI's internal guidelines regarding the ethical conduct of research including the training of enumerators and the development of data management plans. Moreover, informed consent was asked at the beginning of the midline questionnaire, which could only start with the respondent's approval. The midline survey was not submitted to an Institutional Review Board as this was not required for the topics under study.[48] Nevertheless, all due processes were adhered to, ensuring compliance with international ethical standards.

[48] It is important to note that even when not mandatory, engaging in the process of submitting research proposals to an Institutional Review Board is usually advocated for its ethical and procedural rigour.

IV. PRESENTATION OF RESULTS

97. This section presents the descriptive statistics from the 1,654 households interviewed at the midline survey alongside impact estimates utilizing a range of specifications. The descriptive statistics cover household characteristics and then address evaluation questions one to nine, which focus on adaptation, followed by evaluation questions 11 and 12, which focus on mitigation.[49] Within the descriptive statistics, each part compares early beneficiaries (Phase 1) with late beneficiaries (Phase 3). Phase 3 households are households assigned to the third phase of SLEM implementation, which started in late 2022. In this midline IE, Phase 3 households serve as a comparison group for households from the first implementation phase (2019). The narrative refers to relevant baseline findings in footnotes. The results of the descriptive statistics provide suggestive evidence of the potential changes brought by the SLEM activities at midline. However, these initial results may lack precision and be influenced by factors external to SLEM interventions. Our impact estimates allow us to confirm or invalidate the descriptive results by mobilizing statistical methods (described in Sections B and C) to isolate the causal changes due to SLEM from other changes. These methods also help improve the precision of the estimations of the midline impacts of the SLEM. Aspects of interpreting the key project impacts at midline are provided in the section V.

A. DESCRIPTIVE ANALYSIS

1. HOUSEHOLD CHARACTERISTICS

98. Table IV–1 displays information on households' characteristics by SLEM implementation phases. These characteristics do not differ on average between Phase 1 and Phase 3 households, as shown by the lack of statistically significant differences in these variables. As expected, there is also little variation in these variables since the baseline survey.

99. Around 11 per cent of households are headed by women at midline. Survey data reveals a slightly higher proportion of women-headed households within Phase 1 (12.7 per cent at midline)[50] compared to Phase 3 (8.9 per cent at midline).[51] Neither of these differences are statistically significant. In terms of ethnicity, Table IV–1 shows a broadly similar distribution of ethnic groups (all of which are indigenous) across both Phase 1 and Phase 3 households, with no significant differences reported. Similarly, the total number of members in the household (6.2 members on average) is balanced across Phase 1 and Phase 3 households.[52] This is also the case for the average age of respondents (46.5 years on average).[53] The comparison of Phase 1 and Phase 3 households in terms of household composition (ratio total adults/total members, in percentage) is extremely similar (51.6 per cent).[54]

100. In terms of education, we find that Phase 1 households illustrate a slightly higher proportion of households that attended school beyond primary school (40 per cent compared to 35 per cent in

[49] Throughout this part of the report, column 3 displays the p-value of t-tests for the differences in mean values between Phase 1 and Phase 3 groups. Sampling weights are included and standard errors are clustered at the COBA level. Significance levels are indicated by * $p < 0.10$ (10%), ** $p < 0.05$ (5%), *** $p < 0.01$ (1%).
[50] Increasing from 11.4% at baseline.
[51] Decreasing from 10.1% at baseline.
[52] This figure is slightly lower than at baseline which was 6.3 members.
[53] This shows a slight decrease from baseline (47.5 years).
[54] This represents an increase from 42.1% at baseline. This suggests, on average, a very slightly lower number of babies, infants and elderly individuals within households.

Phase 3) but a slightly lower level of primary education (51 per cent compared to 58 per cent in Phase 3), and a slightly higher proportion of households who have never gone to school (8.9 per cent) compared to Phase 3 (7.7 per cent).[55] None of these differences are statistically significant.

101. When we look at how long households have been living in the same village, we see that Phase 1 households have been resident for slightly longer (17.55 years) compared to Phase 3 households (17.17 years), but this difference is not significant.[56] Table IV–1 describes the geographical location of households in relation to the nearest fokontany centre in minutes, as well as the distance from the closest forest. We see no significant differences between Phase 1 (41 minutes) and Phase 3 (46 minutes) households for the former, and nor do we see significant differences in the latter (93 minutes compared to 86 minutes).[57]

102. Table IV–1 concludes by comparing the physical characteristics of housing across Phase 1 and Phase 3 households. For these indicators, characteristics were ordered according to quality/cost and then summed. We observe no significant differences between Phase 1 and Phase 3 households.[58]

Table IV–1. Descriptive statistics for household characteristics at midline

Variable	Category	Phase 1 mean/SD	Phase 3 mean/SD	Test p-value	# obs. Phase 1	# obs. Phase 3
Gender of household head at midline	Woman household head at midline	0.127 [0.333]	0.089 [0.089]	0.144	833	821
Ethnicity at midline	Betsileo	0.191 [0.393]	0.223 [0.416]	0.733	833	821
	Bezanozano	0.109 [0.312]	0.110 [0.312]	0.549	833	821
	Betsimisaraka	0.221 [0.415]	0.192 [0.394]	0.810	833	821
	Tanala	0.286 [0.452]	0.256 [0.437]	0.911	833	821
	Other	0.187 [0.3904]	0.213 [0.410]	0.536	833	821
Number of members in the household at midline		6.14 [2.850]	6.24 [2.585]	0.918	833	821

[55] This may be reflective of the higher proportion of women-headed households within Phase 1 households at midline. Low levels of education may represent a threat to accessing relevant information on agricultural practices, weather and markets. To address this obstacle, the project collaborated with lead farmers and local association leaders to effectively disseminate information throughout the community via oral communication.
[56] It is interesting to note the duration of residence decreased slightly in Phase 1 households (down from 17.76 years) while it increased in Phase 3 households (from 16.62 years).
[57] When we compare these times to baseline values, we note broadly similar figures for distance to the Fokontany centre but considerably greater times in terms of distance to the forest. As households are part of a panel and have not moved themselves (as they were available for the midline survey), this suggests that the quality of roads and paths to the forest have worsened considerably (due to recent cyclones) or that the forest itself is now seen to start further away from households (suggesting deforestation and degradation).
[58] We can also observe a slight improvement in the quality of both house characteristics (roof, wall, floor, number of rooms) and house facilities (electricity, water, latrine) between baseline and midline surveys, suggesting a very slight improvement is the standard of living across both groups.

Variable	Category	Phase 1 mean/SD	Phase 3 mean/SD	Test p-value	# obs. Phase 1	# obs. Phase 3
Age of respondent (in number of years) at midline		46.63 [13.448]	46.40 [13.646]	0.891	832	820
Ratio total adults/total members at midline (in percentage)		51.576 [20.996]	51.700 [20.803]	0.923	833	821
Highest level of education in the household at midline	Household (HH) has never gone to school	0.089 [0.284]	0.077 [0,266]	0.688	833	821
	HH went to elementary school	0.508 [0.500]	0.577 [0.494]	0.166	833	821
	HH above primary education	0.403 [0.490]	0.346 [0.476]	0.192	833	821
Number of years living in the village		17.5498 [16.507]	17.1674 [15.159]	0.338	833	821
Household's distance from fokontany centre (in minutes)		41.16 [54.563]	46.43 [54.274]	0.555	833	821
Household's distance from closest forest (in minutes)		92.76 [76.182]	86.43 [55.190]	0.421	833	821
Housing characteristics [1]		4.957 [1.726]	4.795 [1.660]	0.279	833	821
Housing facilities [2]		1.082 [0.490]	1.045 [0.356]	0.267	833	821

Source: LORTA team
Note: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.
Standard deviations are indicated in square brackets.
[1] Scores from 1 to 3 were assigned to roof, wall and floor materials, with 1 indicating no to little value added and 3 high value added. Housing characteristics are measured as the sum of these scores, varying from 1 to 9.
[2] Housing facilities describe the household's standard of living in terms of the energy source used for cooking. This indicator assigns a score to different sources, which is then aggregated across the main three sources. The final indicator can take the value from 1 (only fuelwood is used) to 24 (liquefied petroleum gas, electricity and solar energy are used).

103. Overall, these results support the robustness of the methodology of this midline evaluation, as no significative differences at the level of 10 per cent or lower were found for any of these variables between households in Phase 1 and households in Phase 3. As sociodemographic characteristics and locational and housing attributes were not expected to be affected by the SLEM interventions, these variables would be expected to balance between Phase 1 and Phase 3 households due to randomization.

2. Livelihood strategies

104. We assess changes in main sources of livelihoods over three categories derived from the literature on livelihood diversification and poverty dynamics: farm livelihoods (crop farming, livestock

farming); off-farm livelihoods (fisheries, harvesting wild forest products, harvesting timber); and non-farm livelihoods (public work, construction and other non-farm livelihoods activities).[59] We further explore agricultural diversification by looking at the number of crops grown by households and average livestock holdings.

105. Table IV–2 highlights that farm-based livelihoods are the most important way of making a living compared to off-farm livelihood strategies and non-farm livelihood strategies. Specifically, 98.4 per cent of Phase 1 respondents stated they conduct farming activities compared to 98.2 per cent of Phase 3 respondents. The average difference is not statistically significant. A higher proportion of Phase 1 households (16 per cent) reported they conducted off-farm livelihoods compared to Phase 3 control treatments (8 per cent), yet the difference is also not statistically significant. However, a statistically significant difference (at the 10 per cent level) can be observed in non-farm activities, which is larger in Phase 1 households (67.1 per cent of respondents) compared to Phase 3 households (53.9 per cent of respondents).[60]

Table IV–2. Descriptive statistics for main sources of livelihoods in the wet season at midline

Variable	Phase 1 mean	Phase 3 mean	T-test p-value	# obs. Phase 1	# obs. Phase 3
Participation in farm livelihoods in the wet season at midline	0.983 [0.128]	0.982 [0.129]	0.869	833	821
Participation in off-farm livelihoods in the wet season at midline	0.012 [0.108]	0.014 [0.120]	0.265	833	821
Participation in non-farm livelihoods in the wet season at midline	0.626 [0.483]	0.571 [0,495]	0.066*	833	821

Source: LORTA team
Note: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

106. Regarding the dry season, Table IV–3 shows a similar pattern to the wet season in that farm livelihoods are the most important way of making a living for both Phase 1 and Phase 3 households, followed by non-farm activities and then off-farm activities. There are two notable points. First, the greater proportion of Phase 1 households conducting non-farm activities remains significant at the 10 per cent level in the dry season. Second, in contrast to the wet season, a greater proportion of Phase 3 households conduct off-farm activities in the dry season than Phase 1 households (although the difference is not statistically significant).[61]

Table IV–3. Descriptive statistics for main sources of livelihood in the dry season at midline

Variable	Phase 1 mean	Phase 3 mean	T-test p-value	# obs. Phase 1	# obs. Phase 3
Participation in farm livelihoods in the dry season at midline	0.956 [0.203]	0.926 [0.260]	0.808	833	821

[59] For example, see Ellis (2000).
[60] Crop farming and livestock farming are categorized as farm livelihoods. Fisheries, harvesting wild forest products, harvesting timber are categorized as off-farm livelihoods. Public work, construction and other non-agricultural activities are categorized as non-farm livelihoods.
[61] The reasons for this are covered in the discussion.

Variable	Phase 1 mean	Phase 3 mean	T-test p-value	# obs. Phase 1	# obs. Phase 3
Participation in off-farm livelihoods in the dry season at midline	0.013 [0.114]	0.035 [0.184]	0.420	833	821
Participation in non-farm livelihoods in the dry season at midline	0.6315 [0.482]	0.6017 [0.489]	0.071*	833	821

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

107. Table IV–4 displays the total number of crops cultivated by households, which barely differs between Phase 1 (5.8 crops on average) and Phase 3 (5.7) households at midline.

Table IV–4. Descriptive statistics for the total number of crops cultivated by the household at midline

Variable	Phase 1 mean	Phase 3 mean	T-test p-value	# obs. Phase 1	# obs. Phase 3
Number of crops cultivated by the household at midline	5.836 [.039]	5.652 [.036]	0.669	833	821

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

108. Table IV–5 illustrates the average livestock holdings in terms of Tropical Livestock Units (TLU). This table shows that Phase 3 (control) households hold a slightly higher number of livestock (with a TLU score of 1.9) compared to Phase 1 treatment households (1.7). The average difference in TLU scores is not statistically significant.

Table IV–5. Descriptive statistics for livestock holdings at midline

Variable	Phase 1 mean	Phase 3 mean	T-test p-value	# obs. Phase 1	# obs. Phase 3
TLU	1.742 [0.054]	1.893 [0.040]	0.662	833	821

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

3. Conservation agriculture practices

109. Conservation agriculture practices are the main adaptation strategies used by farmers in CAZ and COFAV to face climate hazards with potential impacts on agriculture, livestock and forest products. Table IV–6 shows the number of conservation agriculture used by farmers at midline. It shows that

Phase 1 households practice more conservation agriculture practices (3.44 practices adopted) than Phase 3 households (3.26), but this difference is not statistically significant.[62].

Table IV–6. Descriptive statistics for the number of conservation agriculture practices used by farmers at midline

Variable	Phase 1 mean	Phase 3 mean	T-test p-value	# obs. Phase 1	# obs. Phase 3
Number of conservation agricultural practices used by farmers at midline	3.444 [2.090]	3.143 [1.878]	0.349	832	821

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

4. Impacts of climate hazards

110. We now cover the descriptive statistics for the impacts of climate hazards on harvests from agriculture, forest products and livestock. The indicators here cover the percentage of harvest or livestock lost due to any shock, including strong winds, drought, hail, frost or flooding. Table IV–7 shows that Phase 1 (53.3 per cent) and Phase 3 households (53.4 per cent) lost a similar proportion of agricultural harvests. However, we observe differences regarding the percentage of forest products lost, with Phase 3 households reporting an average loss of 16.6 per cent compared to 7.5 per cent among Phase 1 households. This difference is not significant at the 10 per cent level and covers a limited number of observations.[63] Table IV–7 also shows that a higher proportion of livestock died (based on headcount figures) due to any shock in Phase 1 households (7 per cent) compared to Phase 3 households (3.9 per cent), with this difference again not statistically significant.

Table IV–7. Descriptive statistics for loss in agricultural production following weather shocks at midline

Variable	Phase 1 mean	Phase 3 mean	T-test p-value	# obs. Phase 1	# obs. Phase 3
Percentage of harvest decrease due to any shock at midline	53.318 [35.651]	53.355 [33.929]	0.803	824	816
Percentage of harvest loss of forest products due to any shock at midline	7.475 [20.082]	16.645 [30.654]	0.133	190	161
Percentage of animals perishing due to any shock	6.970 [15.392]	3.899 [11.594]	0.195	824	816

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

[62] Interestingly, while the number of conservation agriculture practices completed by Phase 3 households has stayed constant from baseline to midline (3.26), the number reported by Phase 1 households has declined from 3.64 at baseline to 3.44 at endline.
[63] The low number of observations and the large variance of this indicator explain the inability of the mean difference test to detect statistically significant differences between Phase 1 and Phase 3 households despite a large observed difference between these two groups.

5. Agricultural production and use

111. Table IV–8 covers the descriptive statistics for agricultural production. It shows the production of the top five crops (rice, beans, ground nut, bambara peas, ginger) supported by the project and the total value of crop production, livestock production and harvested forest products. Table IV–8 also shows that Phase 3 households produced greater quantities (in kg) of beans, groundnuts and rice, with the two crops showing significance at the 5 and 10 per cent levels, respectively.[64] The table also clearly illustrates the centrality of the forest and forest products within the livelihoods of the whole sample. It shows how households generate the most income from livestock, crops and harvested forest products. Interestingly, Phase 3 households reported higher values (in MGA) for livestock and forest products compared to Phase 1 households, who reported a higher level of crop value. None of these differences are statistically significant.

Table IV–8. Descriptive statistics for households' agricultural production at midline

Variable		Phase 1 mean	Phase 3 mean	T-test p-value	# obs. Phase 1	# obs. Phase 3
Production of top 5 crops (rice, beans, ground nut, bambara peas, ginger) supported by the project at midline	Rice (kg)	234.916 [748.941]	656.129 [1,018.775]	0.721	786	812
	Bean (kg)	28.766 [36.478]	50.782 [134.870]	0.048**	377	383
	Ground nut (kg)	32.239 [46.116]	134.870 [72.993]	0.094*	152	140
	Bambara peas (kg)	34.072 [109.46]	31.557 [74.502]	0.878	62	83
	Ginger (kg)	563.189 [2,116.829]	234.916 [234.917]	0.227	84	10
Total value of crop production at midline (MGA)		2,121,033.958 [2,947,810.414]	1,895,903.392 [1,920,050.411]	0.301	833	821
Total value of livestock production at midline (MGA)		2,525,047.028 [3,152,678.964]	3 152 678.964 [4908685.530]	0.459	833	821
Total value of harvested forest products at midline (MGA)		674 9162.040 [2,644,590.552]	876,349.619 [6,749,162.040]	0.145	833	821

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

112. Table IV–9 illustrates the descriptive statistics for the use of agricultural production. It shows similar figures for Phase 1 and Phase 3 households in terms of the shares of sales (13 per cent for crops, 4.9 per cent for livestock and 1.4 per cent for forest products), as well as in the share of livestock production that was lost (4.6 per cent). None of these differences are statistically significant.

113. However, we do observe some differences which differ meaningfully between Phase 1 and Phase 3 households. For example, the share of crop production that was stored was greater among Phase 1

[64] These significant differences are based on a limited number of observations.

households (2.7 per cent) compared to Phase 3 households (2.1 per cent) (significant at the 10 per cent level). We also see a significant difference (at the 10 per cent level) in terms of the share of livestock production that is stored, with Phase 3 households storing a greater proportion (16.7 per cent) compared to Phase 1 households (13.3 per cent).[65]

Table IV–9. Descriptive statistics for share of agricultural production not used for household consumption at midline

Variable	Phase 1 mean/SD	Phase 3 mean/SD	T-test p-value	# obs. Phase 1	#obs. Phase 3
Share of crop production sold at midline	13.889 [12.161]	12.391 [11.265]	0.510	833	821
Share of crop production stored at midline	2.698 [3.759]	2.131 [3.347]	0.043*	833	821
Share of crop production lost at midline	1.692 [4.274]	3.119 [7.945]	0.617	833	821
Share of livestock production sold at midline	4.903 [6.340]	4.827 [6.403]	0.689	833	821
Share of livestock production stored at midline	13.315 [11.961]	16.671 [13.441]	0.008*	833	821
Share of livestock production lost at midline	4.480 [5.678]	4.750 [5.845]	0.618	833	821
Share of forest product harvest sold at midline	1.183 [5.308]	1.664 [6.573]	0.688	833	821

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

6. Income and expenditure

114. We now turn to Table IV–10, which compares Phase 1 and Phase 3 households in terms of average annual expenditures of households. Phase 1 households reported a higher level of average expenditure at Malagasy ariary (MGA) 1,015,207.58 compared to Phase 3 households at MGA 847,331.11. The difference is not statistically significant.[66]

[65] Changes in agricultural use can be observed over time. The share of crop production that was sold (13%) for the whole sample is considerably lower than the figure at baseline (16.2%), while the share of livestock that was sold (4.9%) at midline is again much lower than the figure at baseline (10.2%). Moreover, this declining trend is also observed in the share of livestock production that was stored with the midline figure (15% overall) reflecting an important reduction from the baseline figure of 35%. We can note a similar trend in the share of forest product harvest that was sold at midline, which has reduced from 6.9% overall at baseline to 1.4% at midline. Overall, the trends through time need to be treated with caution due to seasonality and adjustments in the timing of the survey. The reduced production of crops, livestock and forest products being sold and lower proportion of livestock products being stored could suggest greater immediate food consumption needs within households or the possibility that markets have not been offering price signals that encouraged the sale of commodities (due, for example, to the condition of roads and paths following cyclones).
[66] When we compare these midline figures with the baseline survey, we see that Phase 1 households have reported a larger increase in expenditures of MGA 100,000 (baseline figure is MGA 915 758.15 MGA), compared to an MGA 22,000 increase among Phase 3 households (baseline figure is MGA 825 380.59).

Table IV–10. Descriptive statistics on household expenditures at midline

Variable	Phase 1 mean/SD	Phase 3 mean/SD	T-test p-value	# obs. Phase 1	# obs. Phases 3
Expenditures at midline (MGA)	1,015,207.577 [1,069,926.376]	847,331.106 [939,190.52]	0.450	799	825

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

115. Table IV–11 shows the midline data for self-reported annual household income. Phase 1 households reported an average income slightly larger than Phase 3 households (MGA 1,290,132.90 and MGA 1,276,456.51, respectively). The difference is not statistically significant. This income indicator was only collected for midline, and there is no comparative value within the baseline survey. When we compare the amount of income generated from the five crops promoted by the project, we only see one significant difference, with Phase 3 households reporting higher incomes from beans (at the 10 per cent level). We can also observe a larger income for Phase 1 households from ginger production, yet this is not statistically significant, partly due to the limited number of Phase 3 households adopting this crop.

Table IV–11. Descriptive statistics on household income at midline

Variable	Phase 1 mean/SD	Phase 3 mean/SD	T-test p-value	# obs. Phase 1	# obs. Phase 3
Income (MGA)	1,290,132.896 [1,349 106.864]	1,276,456.512 [1,339,170.605]	0.603	804	822
Income from ginger (MGA)	215,190.474 [517,629.268]	149,696.309 [214,607.014]	0.329	251	38
Income from Bambara peas (MGA)	22,409.250 [51,043.015]	16,158.252 [46,186.986]	0.597	446	503
Income from groundnuts (MGA)	41,830.662 [69,556.456]	46,918.264 [59,916.475]	0.695	864	678
Income from beans (MGA)	37,274.764 [70,732.668]	48,300.885 [83,013.625]	0.057*	389	363
Income from rice (MGA)	145,666.907 [345,934.279]	166,824.708 [359,294.327]	0.398	797	789

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

7. Food security

116. Table IV–12 displays findings from the CARI FSI.[67] The index ranges from 1 (food secure) to 4 (severely food insecure). Overall, a large share of households is food insecure, with 41.3 per cent of all households interviewed at midline being moderately food insecure and 16.2 per cent of

[67] Appendix 3 provides full details of the calculation of the CARI index.

households severely food insecure.[68] At midline, we observe a slightly higher level of food insecurity among Phase 3 households (2.75 on average) than among Phase 1 households (2.55) (see Table III–2). This difference is statistically significant at the 10 per cent level, suggesting that the project interventions may have mitigated the increase in food insecurity across all households.[69] The accuracy of this result will be assessed in the next subsection, which presents the IE estimates. The average number of days without food is slightly higher for Phase 1 households (56 days against 51 for Phase 3 households). However, this difference is not statistically significant.

Table IV–12. Descriptive statistics on food security at midline

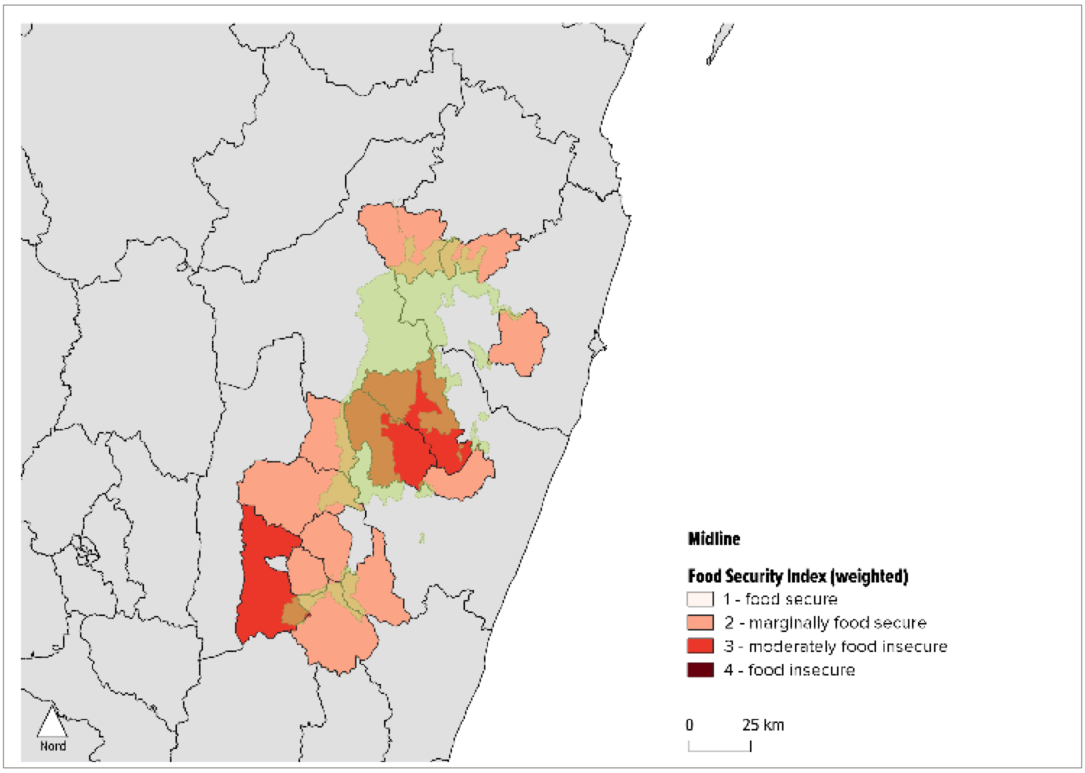
VARIABLE	PHASE 1 MEAN	PHASE 3 MEAN	T-TEST P-VALUE	# OBS. PHASE 1	# OBS. PHASE 3
Food security index (CARI) at midline (in units)	2.547 [0.770]	2.747 [0.740]	0.089*	833	821
Number of days without food at midline	55.730 [68.506]	50.537 [61.374]	0.539	831	820

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

117. Figure IV–1 and Figure IV–2 below show the average food security level of households by municipality in CAZ and COFAV, respectively. On average, COFAV displays a more significant level of food insecurity than in CAZ at midline.[70]

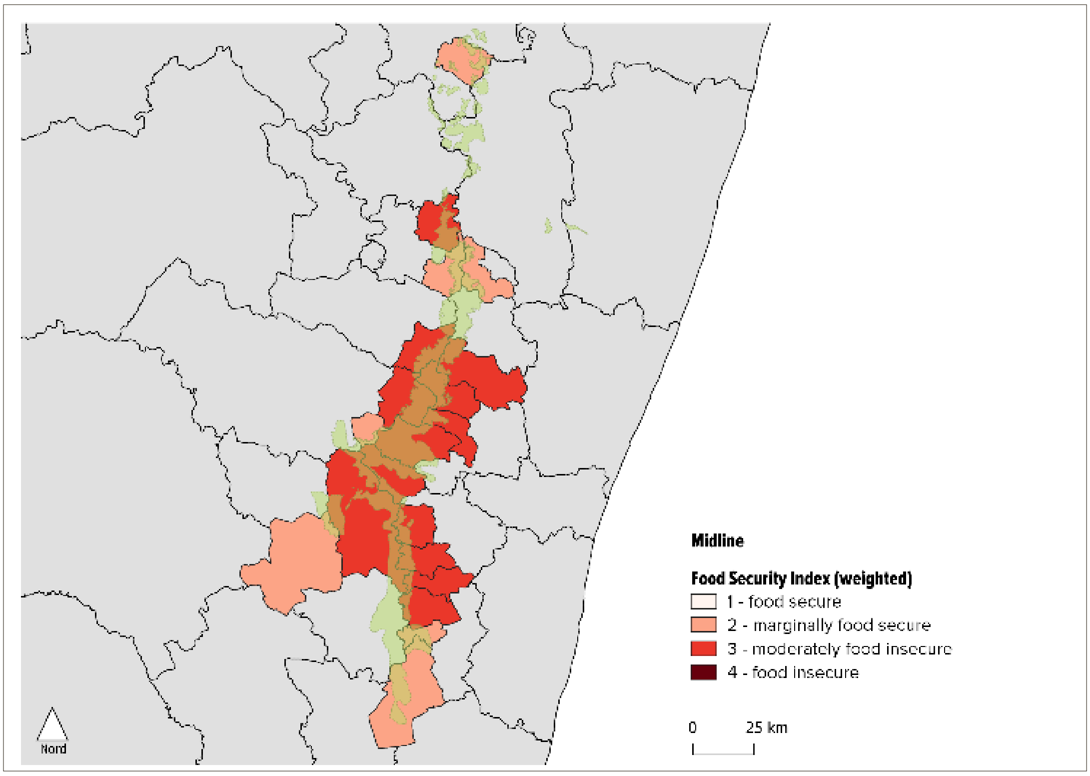
[68] The situation has worsened since the baseline when only 10% of households reported being severely food insecure.
[69] When decomposing by category of food security, we observe a statistically significant larger share of early beneficiaries (Phase 1 households) that are food secure in comparison with late beneficiaries (Phase 3 households). This suggests that the project may have supported marginally food secure households, while it did not have a significant impact on more vulnerable households.
[70] The municipalities, where the midline survey took place are:
CAZ: Ambodilazana, Ambohibary, Ambohimanana, Ampasimpotsy Gare, Andasibe, Antenina, Beforona, Fetraomby, Fierenana, Lakato, Manakambahiny Est, Maroseranana, Morarano Gara.
COFAV: Alatsinainy Lalamarina, Ambatombitro, Ambohimahamasina, Ambohimana, Ambohimitombo I, Ambolomadinika, Ampatsy Ampangabe, Androy, Ankarimbelo, Ankazotsararavina, Antodinga, Ikongo, Ivato, Ivohibe, Ivongo, Mahazoarivo, Manambidala, Miarinarivo, Moroteza, Namoly, Tolongoina, Vinanitelo, Vohiboreka, Vohimary Sud, Vondrozo.

Figure IV–1. Map of CAZ municipalities and their level of food security



Source: Conservation International

Figure IV–2. Map of COFAV municipalities and their level of food security



Source: Conservation International

8. Vulnerability

118. The vulnerability index ranges from 1, indicating a marginally vulnerable household, to 4, indicating an extremely vulnerable household.[71] Overall, the average vulnerability index at midline for the interviewed households is 2.36. This means that, on average, the sample size presented a moderate climate change vulnerability. Most of the households at midline are considered moderately vulnerable (40.9 per cent), followed by severely vulnerable (34.7 per cent). Only 17.7 per cent of the households interviewed are marginally vulnerable, and 6.7 per cent are extremely vulnerable.

119. Table IV–13 below presents the results on the vulnerability index, combining the households in CAZ and COFAV. No statistically significant difference exists between households' average climate change vulnerability in phases 1 and 3 at midline. The three components of the climate vulnerability index – exposure, sensitivity and adaptive capacity – also did not show statistically significant differences between phases 1 and 3 (see Appendix 4 for more details on these indicators' calculations).

Table IV–13. Descriptive statistics on vulnerability to climate change at midline

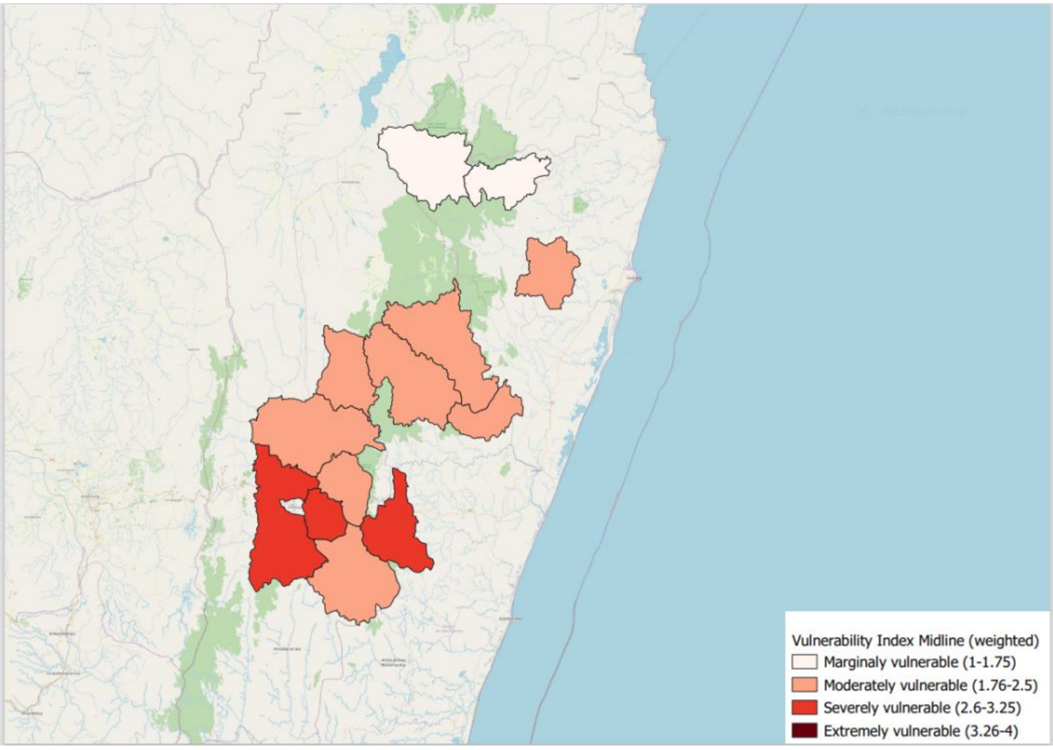
Variable	Phase 1 mean	Phase 3 mean	T-test p-value	# obs. phase 1	# obs. phase 3
Vulnerability index at midline (units)	2.364 [0.577]	2.342 [0.563]	0.795	699	715
Exposure at midline (units)	2.038 [1.160]	2.048 [1.182]	0.888	779	790
Sensitivity at midline (units)	2.496 [0.886]	2.403 [0.787]	0.505	733	747
Adaptive capacity at midline (units)	2.534 [0.466]	2.589 [0.445]	0.527	782	765

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

120. Figure IV–3 and Figure IV–4 below show the average vulnerability index of households by municipality in CAZ and COFAV, respectively. While municipalities with severely vulnerable households are more common in the southern part of CAZ, municipalities with severely vulnerable households are spread through COFAV. The remaining municipalities were classified as moderately vulnerable in both CAZ and COFAV, except for two in the northern part of CAZ, which were classified as marginally vulnerable at midline.

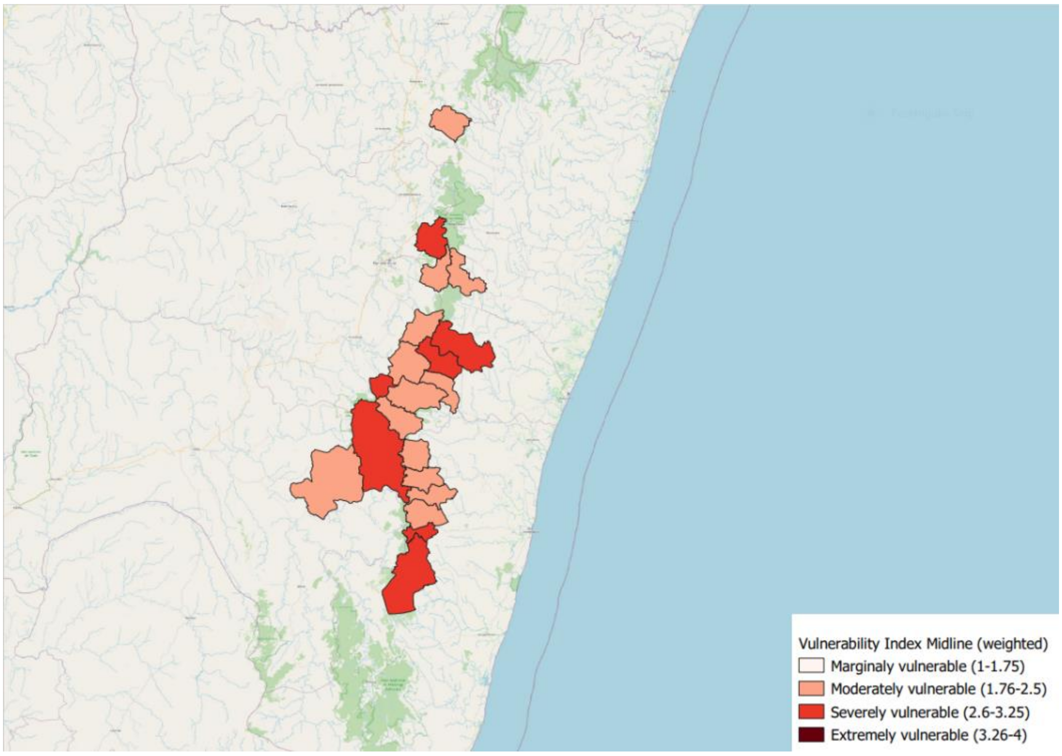
[71] Appendix 4 provides full details of the calculation of the vulnerability index.

Figure IV–3. Map of CAZ municipalities and household vulnerability to climate change



Source: Conservation International

Figure IV–4. Map of COFAV municipalities and household vulnerability to climate change



Source: Conservation International

9. Mitigation

121. Table IV–14 below offers descriptive statistics from key mitigation indicators. The first set of indicators report the satisfaction level with the level of protection in the CAZ/COFAV forest corridor (including the regulations, patrolling, law enforcement, etc.). At midline, we see that around 13 per cent of respondents are not at all satisfied, 17 per cent are slightly satisfied, 37 per cent are moderately satisfied, 25 per cent are very satisfied, and 8 per cent are extremely satisfied. None of these indicators show significant differences between Phase 1 and Phase 3 households.[72]

Table IV–14. Descriptive statistics on the level of protection in CAZ/COFAV forest corridor at midline

Variable	Phase 1 mean/SD	Phase 3 mean/SD	T-test p-value	# obs. phase 1	# obs. phase 3
Satisfaction level with the protection in CAZ/COFAV forest corridor (regulations, patrolling, law enforcement, etc.)					
Not all satisfied midline	0.143 [0.350]	0.132 [0.338]	0.640	833	821
Slightly satisfied midline	0.175 [0.380]	0.154 [0.360]	0.331	833	821
Moderately satisfied midline	0.366 [0.482]	0.372 [0.483]	0.138	833	821
Very satisfied midline	0.227 [0.419]	0.270 [0.444]	0.652	833	821
Extremely satisfied midline	0.089 [0.285]	0.073 [0.260]	0.186	833	821

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

122. Table IV–15 offers descriptive statistics on the perceived importance of the COBA in helping to manage the forests and natural resources more sustainably and equitably. Overall, at midline, 33 per cent of respondents reported that the COBA was extremely important, 55 per cent reported it was important, 4 per cent reported it was of little importance, and 1.5 per cent reported it was not at all important. We see a larger proportion of Phase 3 households reporting the COBA was important (58 per cent) compared to 53 per cent of Phase 1 households (statistically significant at the 10 per cent level).[73]

[72] We observe changes in the levels of satisfaction between the baseline and midline surveys. For example, fewer households are now extremely or very satisfied, and more households are slightly satisfied and not at all satisfied. One statistically significant difference at baseline (where 16% of Phase 1 were not at all satisfied compared to only 9% of Phase 3 households) no longer holds at midline.

[73] When we compare the midline figures to baseline estimates (not shown), we see a broadly similar distribution of responses with most households (88%) reporting that the COBA is extremely important or important.

Table IV–15. Descriptive statistics on the importance of the COBA in the sustainable and equitable management of forest and natural resources at midline

VARIABLE	PHASE 1 MEAN/SD	PHASE 3 MEAN/SD	T-TEST P-VALUE	# OBS. PHASE 1	# OBS. PHASE 3
How important is the COBA in helping to manage the forests and natural resources more sustainably and equitably at midline?					
Not all important	0.018 [0.133]	0.012 [0.110]	0.192	833	821
Of little importance	0.046 [0.209]	0.039 [0.194]	0.984	833	821
Average importance	0.050 [0.218]	0.054 [0.225]	0.622	833	821
Important	0.527 [0.499]	0.576 [0.494]	0.084*	833	821
Extremely important	0.345 [0.478]	0.298 [0.458]	0.100	833	821

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

123. Table IV–16 provides descriptive statistics on the quantity of charcoal harvested in the last 12 months before the midline survey. This quantity is slightly larger among Phase 1 households (16.64kg) than Phase 3 households (13.34 kg). This difference is not statistically significant.

Table IV–16. Descriptive statistics on charcoal harvests at midline

VARIABLE	PHASE 1 MEAN	PHASE 3 MEAN	T-TEST P-VALUE	# OBS. PHASE 1	# OBS. PHASE 3
Quantity of charcoal harvested (kg)	16.641 [154.954]	13.341 [124.172]	0.810	824	816

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard deviations are indicated in square brackets.

B. IMPACT ESTIMATES

124. The clustered randomized phase-in design allows us to pinpoint the short-term causal effects of project activities on the key outcomes of interest, notably on food security and vulnerability. Due to the randomized design, causal effects are identified through a comparison of the average outcomes at midline of households randomly allocated to Phase 1 (early beneficiaries) with the average outcomes at midline of households randomly allocated to Phase 3 (late beneficiaries) and those yet to receive the SLEM interventions at the time of the midline survey.

125. The structure of this section is as follows. We organize the impact estimates based on our evaluation questions with a description of results accompanied by tables illustrating the coefficients and relevant tests. We display results from the main specification (v4) with the widest range of covariates. The main specification presented below includes the following set of covariates: randomization strata fixed effects, key household characteristics at baseline (gender of head, age,

ethnicity, number of adults, number of children, education level, land ownership in logged hectares), key baseline outcome variables (food security status and logged expenditures) as well as variables that differed significantly at baseline and those that did so when testing for differential attrition.[74]

126. The main reference point is the impact tables in Appendix 8, which summarize version 3 (v3) and version 4 (v4) coefficients for our three models of the estimation of SLEM midline impacts: (i) estimation of ITT, (ii) estimation of LATE, and (iii) estimation of DiD with random effects (RE).

127. The ITT estimates measure the impacts of belonging to a household member of a COBA assigned to receive SLEM interventions in 2019 (Phase 1 COBAs), irrespective of the actual reception of SLEM interventions. In contrast, the LATE estimates measure the impacts of the SLEM on households of the sample that reported having benefited from one or several SLEM activities.

128. The DiD estimates also measure the impacts of belonging to a household member of a COBA assigned to receive SLEM interventions in 2019 (Phase 1 COBAs). In contrast to the ITT estimates, this method compares changes in outcomes between Phase 1 and Phase 3 households before and after the start of SLEM intervention in Phase 1 areas. DiD estimates account for initial differences between Phase 1 and Phase 3 households that remained stable between the baseline and midline survey.

129. The ITT and DiD estimates differ in their dependence on different identifying assumptions of the SLEM impacts and use the data at hand differently. As some of these assumptions cannot be tested, both approaches are used to gain more confidence in the results. More information on these respective models is available in section III.B.

130. The impact table includes estimates from one (v3) of three additional specifications (v1 – v3) with more restrictive sets of covariates to demonstrate that the results are robust regarding the choice of covariates.[75] Furthermore, heterogeneity analysis by gender of household head, residence in CAZ and COFAV, the initial level of vulnerability, and distance to forests is presented in Appendix 9, where each variable interacts with the treatment dummy to assess if the impacts of SLEM adaptation activities differ by subgroup. A summary of the heterogeneity results is in the section C.

131. As with the descriptive statistics, we first cover adaptation evaluation questions before turning to the mitigation evaluation questions.

1. SOURCES AND NUMBER OF LIVELIHOOD STRATEGIES

132. Our first evaluation question assesses whether implementing adaptation interventions has changed the sources and numbers of livelihoods. We assess changes in the main sources of livelihoods over farm livelihoods (crop farming, livestock farming), off-farm livelihoods (fisheries, harvesting wild forest products, harvesting timber) and non-farm livelihoods (public work, construction and other non-farm livelihoods activities). We also look at the number of crops households grow and average livestock holdings.

133. Table IV–17 shows the results of our impact estimates on the proportion of households conducting farm, off-farm and non-farm livelihood strategies within treatment and control households. A consistent trend is observed whereby a different proportion of Phase 1 households conduct these

[74] The version 1 specification only included strata fixed effects. Version 2 added key household characteristics at baseline (gender of head, age, ethnicity, number of adults, number of children, education level, land ownership in log ha. Version 3 added key baseline outcomes (logged expenditures and food security). Version 4 added the variables that differed at baseline based on the balance tests illustrated in the section on attrition.

[75] v3 include the same set of covariates as v4 apart from the variables that differed in balance tests performed at baseline. Estimates from v1 and v2 specifications for the main approach, DiD with random effects and LATE estimates are available on request.

activities in both the wet and dry seasons compared to control households (Phase 3). While the significance level consistently shows statistical significance at the 1 per cent level, the increase in the proportion of treatment households conducting farm activities across both seasons is limited (1 to 2 percentage points). We can observe a more meaningful increase for non-farm activities, with Phase 1 households 7 percentage points more likely to participate in non-farm activities in the wet season and 8 percentage points more likely to participate in the dry season. Changes in off-farm activities show a mixed pattern, with treatment households showing a very small increase in the wet season (1 percentage point) and a similar decrease in the dry season.

Table IV–17. Impact estimates for participation in PICSA[76] trainings

EQ1	Impact		Control mean	Observations
Participation in farm livelihoods in the wet season at midline	0.01	***	0.98	1640
	(0.01)			
Participation in off-farm livelihoods in the wet season at midline	0.01	***	0.02	1260
	(0.01)			
Participation in non-farm livelihoods in the wet season at midline	0.07	***	0.57	1640
	(0.04)			
Participation in farm livelihoods in the dry season at midline	0.02	***	0.93	1640
	(0.02)			
Participation in off-farm livelihoods in the dry season at midline	-0.01	***	0.04	1640
	(0.01)			
Participation in non-farm livelihoods in the dry season at midline	0.08	***	0.54	1640
	(0.04)			
Number of crops cultivated by the household	0.17		5.74	1640
	(0.30)			
TLU	0.02		1.74	1640
	(0.26)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from Ordinary Least Squares (OLS) or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households. Standard errors are indicated in parentheses.

134. When we assess the range of estimates across v4 and v3 specifications (that is, the two specifications with the most comprehensive range of control covariates as described above) for DiD with RE and LATE as shown in the impact table (see Appendix 8), we find that four of the sets of

[76] PICSA stands for Participatory Integrated Climate Services.

estimates show significance across all three livelihood groupings in the wet season. Overall, we find an increase in the proportion of Phase 1 households conducting farm livelihoods (1 to 3 percentage points), off-farm livelihoods (1 to 5 percentage points) and non-farm livelihoods (1 to 9 percentage points) in the wet season, all significant at the 1 per cent level. In the dry season, the direction of change and significance level falls away for non-farm livelihoods in the DiD RE estimates.

135. In the dry season, we also find an increase in farm livelihoods (2 to 3 percentage points) significant at the 1 per cent level. Off-farm livelihoods do not show a consistent direction of change. Neither the number of crops grown (0.11 to 0.17 more than Phase 3 households for the main specification and LATE estimates) nor greater livestock holdings (0.01 to 0.02 TLU for the main specification and LATE estimates) show statistical significance.[77]

2. Number of conservation agriculture practices implemented

136. The second evaluation question focuses on the number of conservation agriculture practices implemented. Table IV–18 shows the number of practices implemented across Phase 1 and Phase 3 (control) households.

Table IV–18. Midline impacts on the number of conservation agriculture practices implemented

EQ2	Impact		Control mean	Observations
Soil conservation used at midline	0.09	***	0.44	1640
	(0.04)			
Agroforestry used at midline	0.04	***	0.35	1640
	(0.04)			
Terracing used at midline	0.04	***	0.22	1640
	(0.05)			
Resistant crops used at midline	0.04	***	0.09	1640
	(0.03)			
Multi-crops used at midline	-0.01		0.48	1640
	(0.04)			
Irrigation used at midline	-0.01		0.56	1640
	(0.05)			
Off-season rice used at midline	0.13	***	0.36	1640
	(0.05)			
Storage used at midline	0.06	***	0.20	1640
	(0.04)			
Pest management used at midline	-0.10	***	0.39	1640
	(0.04)			
Saving groups used at midline	0.06	***	0.06	1640
	(0.03)			
Percentage of households (HH) that implement at least one	0.02	***	0.91	1640

[77] Neither of these indicators were available in the baseline dataset for the DiD RE analysis.

EQ2	Impact	Control mean	Observations
practice at midline			
	(0.02)		
Number of conservation agricultural practices adopted at midline	0.33	3.15	1639
	(0.23)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households. Standard errors are indicated in parentheses.

137. Table IV–18 shows how Phase 1 households are more likely to be practising soil conservation measures (9 percentage points above the control group figure of 0.44), agroforestry techniques (4 percentage points above the control group mean of 0.35), terracing (4 percentage points above the control group figure of 0.22) and climate resistant crops (4 percentage points above the control group figure of 0.09).

138. Table IV–18 also shows that Phase 1 households are more likely to be practising more off-season rice production (13 percentage points above the control figure of 0.36), better storage practices (6 percentage points above the control mean of 0.20) and are participating more in savings groups with a doubling of the control group mean of 0.06. A surprising result is that fewer Phase 1 households are likely to conduct pest management activities, corresponding to 10 percentage points under the control group mean of 0.39. Overall, we can see that Phase 1 households are more likely to conduct at least one conservation agriculture technique (at 2 percentage points above the control group figure of 0.91). On the other hand, although Phase 1 households are, on average, practising 0.33 more conservation agriculture practices than Phase 3 households (with an average of 3.15 per household), this difference is not statistically significant. In addition, Phase 1 and Phase 3 households do not show significant differences for irrigation or multi-cropping.

139. When we assess the range of estimates in the impact table with v4 and v3 specifications for the main estimates, DiD with RE and LATE, we find the following conservation agriculture techniques show a consistent range of coefficients across all six sets of estimates:

- Soil conservation (2 to 13 percentage points at the 1 per cent level)
- Agroforestry (2 to 6 percentage points at 1 per cent level, except for DiD RE v4)
- Terracing (1 to 6 percentage points at 1 per cent level)
- Resistant crops (2 to 6 percentage points at the 1 per cent level)
- Off-season rice (5 to 20 percentage points at the 1 per cent level)
- Storage (2 to 9 percentage points at the 1 per cent level, except for DiD RE v4)
- Savings groups (4 to 10 percentage points at the 1 per cent level)
- Reduction in the proportion of households practising pest management strategies (7 to 10 percentage points at the 1 per cent level)

140. Multi-cropping, irrigation and the number of conservation agricultural practices do not show consistent levels of significance. The percentage of households implementing conservation agricultural practices shows mixed directions, with both DiD RE estimates not showing a positive change.

3. Reduction in damage following a climate hazard

141. The third evaluation question covers the degree to which the project reduced damage following a climate hazard. Table IV–19 illustrates that while Phase 1 households show a reduction in the percentage harvest decrease due to any climate shock for both the top crop produced and the top forest product harvested, neither of these differences are statistically significant. A similar result is seen in the percentage of main livestock species that perished due to shock. The absence of significance for these indicators is similar to our alternative specifications in the impact table.

Table IV–19. Midline impacts on the reduction in agricultural damage following a climate hazard

EQ3	Impact	Control mean	Observations
Percentage harvest decrease due to any shock at midline	-1.98	53.16	1626
	(3.52)		
Percentage of harvest decrease due to any shock at midline	-0.95	5.08	790
	(1.80)		
Percentage of livestock that perished due to any shock at midline	0.53	6.45	1471
	(1.37)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households. Standard errors are indicated in parentheses.

4. Increase in agricultural production and sales

142. Evaluation question four focuses on whether implementing the SLEM interventions increased agricultural production and sales, covering crops, livestock and forest products, as shown in Table IV–20.[78] As indicators of agricultural production display a left-skewed distribution, we applied an inverse hyperbolic sine transformation to these indicators. This transformation reduces the sensitivity of the results to extreme upper values and allows us to accommodate for zero values.

143. In contrast to the output level differences observed in adopting livelihood and conservation agriculture strategies, these outcome-based indicators do not show a consistent direction or level of change. Only one indicator shows significance (at the 5 per cent level): ginger production.[79] This shows a considerable increase for Phase 1 households compared to Phase 3 control households. These results are mostly robust to our alternative specifications, as detailed in Table IV–20.

[78] As indicators of agricultural production display a left-skewed distribution, we applied an inverse hyperbolic sine transformation to these indicators. This transformation reduces the sensitivity of the results to extreme upper values and allows us to accommodate for zero values.
[79] Ginger is a resistant crop and grows underground. It is often grown on slopes and tends to be more resilient to cyclones and floods. However, ginger may damage soil fertility and it was recommended by the project steering committee not to support ginger production. Some Phase 1 households initially received ginger as part of the project interventions.

Table IV–20. Midline impacts on agricultural production and sales

EQ4	Impact		Control mean	Observations
Rice production at midline (in kg, inverse hyperbolic sine transformation)	0.00		6.45	1640
	(0.10)			
Bean production at midline (in kg, inverse hyperbolic sine transformation)	-0.19		1.69	1639
	(0.20)			
Groundnut production at midline (in kg, inverse hyperbolic sine transformation)	0.03		0.64	1640
	(0.16)			
Bambara peas production at midline (in kg, inverse hyperbolic sine transformation)	-0.11		0.33	1639
	(0.12)			
Ginger production at midline (in kg, inverse hyperbolic sine transformation)	0.24	**	0.05	1640
	(0.11)			
Total value of crop production (in MGA, inverse hyperbolic sine transformation)	0.00		14.76	1640
	(0.11)			
Total value of livestock production at midline (in MGA, inverse hyperbolic sine transformation)	-0.37		13.23	1636
	(0.40)			
Total value of forest production at midline (in MGA, inverse hyperbolic sine transformation)	0.36		5.85	1626
	(1.00)			
Share of crop production that was sold at midline	0.36		12.44	1640
	(1.03)			
Share of livestock production that was sold at midline	-0.21		4.84	1637
	(0.70)			
Share of forest product harvest that was sold at midline	-0.20		1.45	1633
	(0.50)			

Source: LORTA team

Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households. Standard errors are indicated in parentheses.

5. Increase in income and expenditure

144. The fifth evaluation question focuses on how implementing adaptation interventions increased income or expenditure. Table IV–21 illustrates income from five key projects-supported crops

alongside total annual household income and expenditure.[80] As for indicators of agricultural production, we applied an inverse hyperbolic sine transformation to these indicators.

145. Table IV–21 shows that from the five project-supported crops (rice, beans, groundnuts, Bambara peas, ginger), only one crop showed a meaningful difference: Phase 1 households showed a statistically significant decrease in income from the sale of beans, corresponding to close to a quarter of the Phase 3 control group mean. More broadly, Phase 1 treatment households reported a higher level of expenditure, significant at the 10 per cent level. These results are not consistently robust to our alternative specifications in the impact table.

Table IV–21. Midline impacts on income and expenditure

EQ5	Impact		Control mean	Observations
Income from rice selling at midline (in MGA, inverse hyperbolic sine transformation)	-0.75		5.74	1573
	(0.66)			
Income from bean selling at midline (in MGA, inverse hyperbolic sine transformation)	-1.70	**	6.93	750
	(0.78)			
Income from groundnut selling at midline (in MGA, inverse hyperbolic sine transformation)	-1.03		7.18	285
	(1.05)			
Income from bambara peas selling at midline (in MGA, inverse hyperbolic sine transformation)	0.43		3.13	142
	(1.26)			
Income from ginger selling at midline (in MGA, inverse hyperbolic sine transformation)	0.82		8.62	91
	(2.16)			
Total annual household income at midline (in MGA, inverse hyperbolic sine transformation)	-0.06		14.18	1612
	(0.11)			
Household expenditures at midline (in MGA, inverse hyperbolic sine transformation)	0.14	*	15.08	1608
	(0.08)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households. Standard errors are indicated in parentheses.

[80] It is important to note these indicators are based on self-reported figures from respondents across broad income/expenditure categories, and not the more refined approach taken during the Living Standards Measurement Survey. Similar to the indicators of agricultural production, we applied an inverse hyperbolic sine transformation to these indicators.

6. Increase in food security

146. Evaluation question 6 focuses on food security, specifically household status on the CARI FSI, alongside one further indicator, the number of days each month during which the household did not have enough food to eat. As described in section IV, the FSI ranges from 1 (food secure) to 4 (severely food insecure).[81] Table IV–22 below reconfirms the descriptive finding and shows how Phase 1 households showed an improvement of 14 decimal points compared to the Phase 3 control group mean of 2.47 (significant at the 5 per cent level). In terms of the number of days without food in the last 12 months, Table IV–22 shows that Phase 1 households reported 2.54 days more than Phase 3 households (control group mean of 48.43 days), yet this difference is not statistically significant.

147. The impact table shows a consistent set of estimates illustrating an improvement in food security status as represented by the CARI index across all six specifications from 5 to 17 decimal points at the 5 and 10 per cent levels.[82] The number of days without food in the last 12 months does not show significance across five of the six sets of estimations.

Table IV–22. Midline impacts on food security

EQ6	Impact		Control mean	Observations
CARI at midline (units)	-0.14	**	2.47	1640
	(0.07)			
Number of days without food in the last 12 months at midline	2.54		48.43	1637
	(6.44)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households. Standard errors are indicated in parentheses.

7. Reduction of households' climate vulnerability

148. As described in section IV, the climate vulnerability index ranges from 1, indicating a marginally vulnerable household, to 4, indicating an extremely vulnerable household. The descriptive statistics showed no statistically significant difference between Phase 1 and Phase 3 households at midline. Table IV–23 shows that the impact estimates report no significant differences between Phase 1 and Phase 3 households in terms of both the index and constituent components. These results are robust to our alternative specifications.

Table IV–23. Midline impacts on households' climate vulnerability

EQ7	Impact	Control mean	Observations
Vulnerability index at midline (units)	0.01	2.34	1214

[81] Within the descriptive statistics, we saw that treatment Phase 1 households were slightly more food secure (significant at the 10% level), suggesting that the project interventions may have mitigated the increase in food insecurity of its beneficiaries.
[82] The CARI index ranges from 1.00 (food secure) to 4.00 (severely food insecure).

EQ7	Impact	Control mean	Observations
	(0.06)		
Exposure index at midline (units)	-0.05	2.11	1553
	(0.11)		
Sensitivity index at midline (units)	0.01	2.36	1290
	(0.10)		
Adaptive capacity index at midline (units)	-0.02	2.55	1492
	(0.04)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households. Standard errors are indicated in parentheses.

149. As we have covered the key adaptation evaluation questions, we will now examine the mitigation evaluation questions.

8. Enforcement of regulations for forest protection

150. Evaluation question 11 focuses on the degree to which patrolling leads to better forest area protection. The midline survey offers two indicators, as described in Table IV–24. The first of these refers to household satisfaction level with the level of forest corridor protection. Here we see a slight increase within Phase 1 household but no statistical significance. The second is household perceptions of the importance of the COBA in helping manage forests and natural resources. Again, we see a slight increase within Phase 1 households but no statistical significance. The impact table also does not show statistical significance for both variables in a consistent manner.[83]

Table IV–24. Midline impacts on the perceived enforcement of regulations for forest protection

EQ11	Impact	Control mean	Observations
Satisfaction level with the level of forest corridor protection at midline (units)	0.04	3.00	1617
	(0.09)		
Importance of the COBA in helping manage forests and natural resources at midline (units)	0.08	3.88	1602
	(0.13)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households. Standard errors are indicated in parentheses.

[83] The endline survey will aim to include data from patrol logs to better understand the extent and frequency of patrolling activities.

9. Reduction in deforestation

151. Evaluation question 12 concerns the degree to which patrolling interventions result in a reduction in deforestation. Table IV–25 details three indicators, the first two of which describe participation in income-generating activities based on non-environmentally sustainable activities in the summer or winter. Table IV–25 highlights that treatment (Phase 1) households are less likely to derive income from non-environmentally sustainable activities than Phase 3 households, with a reduction of 1 percentage point from a group mean of 0.06 in summer and a reduction of 4 percentage points from a group mean of 0.12 in winter. Both results are significant at the 1 per cent level. In contrast, the third indicator suggests that Phase 1 households harvested more charcoal, yet this difference was not statistically significant.

152. These results are robust to our alternative specifications, with a reduction in participation in non-environmentally sustainable income-generating activities of 1 to 3 percentage points in the summer and 4 to 7 percentage points in the winter. The quantity of charcoal production is not significant across any specification.

Table IV–25. Midline impacts on factors of deforestation

EQ12	Impact		Control mean	Observations
Deriving income from non-environmentally sustainable activities in the wet season at midline	-0.01	***	0.06	1640
	(0.01)			
Deriving income from non-environmentally sustainable activities in the dry season at midline	-0.04	***	0.12	1640
	(0.02)			
Quantity of charcoal produced at midline (kg)	7.24		11.51	1626
	(11.55)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households. Standard errors are indicated in parentheses.

C. Heterogeneity

153. This section describes the differences between Phase 1 and Phase 3 household subgroups, with full details provided in Appendix 7. We present this heterogeneity analysis by gender of household head, location in CAZ or COFAV, interaction with distance and interaction with the initial level of vulnerability.

154. In terms of the proportion of households engaged in livelihood strategies, Appendix 9 shows that the increased adoption of non-farm livelihoods is driven by women-headed households in both wet and dry seasons.[84] It is also driven by households (by household heads of either gender) in COFAV.

[84] Both men and women are significantly involved in crop farming activities in rural Madagascar. However, women-headed households tend to have a lower access to land, resources and labour force. As a result, women-headed households tend to work on smaller plots and may have larger incentives in diversifying their source of income outside of agriculture.

155. Regarding the number of conservation agriculture practices, the heterogeneity analysis illustrates that women-headed households drive the adoption of soil conservation practices and terracing. In contrast, households headed by men drive the adoption of resistant crops, off-season rice, the reduction of pest management practices, and the adoption of saving groups.

156. We also observe considerable differences between CAZ and COFAV landscapes. Households' resident in CAZ are driving the increase in adoption of all the conservation agriculture techniques that show statistical significance apart from terracing and pest management. In other words, soil conservation, agroforestry, resistant crops, multi-crops, off-season rice and saving groups. Interestingly, the reduction of adoption of pest management techniques is driven by household's resident in COFAV. The dominance of CAZ households in terms of adoption of conservation agriculture techniques is reflected in the proportion of households practising one or more conservation agricultural practices, showing an increase of 69 percentage points in CAZ, which is significant at the 1 per cent level compared to an insignificant difference of 14 percentage points in COFAV.

157. A few differences in adopting conservation agricultural practices are also observed, according to the distance from the forest and the initial level of vulnerability. The impacts of the project on the likelihood of adopting soil conservation and irrigation are moderated by the distance from the forest, though the magnitude of these differences is marginal. In contrast, the observed reduction of pest management techniques and increased adoption of savings groups are unaffected by distance from the forest. Regarding the initial level of vulnerability, we observe that its status moderates the project's impact on the adoption of resistant crops (at the 5 per cent level of significance). We also observe that initial vulnerability moderates the project's impact by changing the likelihood of adopting savings groups (at the 5 per cent level of significance).

158. When we turn to the damage resulting from a climate hazard, we observe that the gender of the household head influences the project's impact on harvest losses. While households headed by men are not significantly affected, the project leads to more significant losses in women-headed households' crop harvests following a climate hazard (significant at the 10 per cent level).[85] The project's impact is also moderated by distance from the forest (significant at the 5 per cent level). We also observe how the initial level of vulnerability moderates the impact of the intervention on harvest losses (with significance at the 10 per cent level).

159. There is little difference in the project's impact on ginger production by gender of the household head. However, differences are observed by location of residence, with this impact being driven by households in CAZ (at the 10 per cent level of confidence). Similarly, impacts on bean and groundnut production are also concentrated in the CAZ area. When distinguishing by initial vulnerability, the project's impact on ginger production is mainly found among households with a high level of initial vulnerability. Surprisingly, we find that the impact of the project on livestock production is negative for households headed by men (at the 10 per cent level) and that the impact of the project on the share of livestock sales is driven by women-headed households (significant at the 10 per cent level). Distance from the forest slightly moderates the impact of the project on bean production (at the 10 per cent level of significance), the value of livestock and forest production (at the 10 per cent level), and livestock sales (at the 1 per cent level).

In our sample, the area of land cultivated by women-headed households is on average half that of male-headed households (1.09 hectares against 2.22 hectares).

[85] This result may come from a reallocation of the time of women-headed households towards non-farm activities, as a result of their participation in the project. However, it is important to note that the size of the sample of women-headed households having encountered shocks is limited, negatively impacting the confidence level associated with this particular finding. However, if this result is not a statistical anomaly, it raises concerns and warrants further investigation at endline.

160. Concerning income and expenditure, the results suggest that project activities negatively impact income derived from crops for some subgroups. We observe a decrease in income from groundnuts (at the 5 per cent level) and Bambara peas (at the 10 per cent level) in women-heading households, as well as a decrease in income from rice (at the 5 per cent level) and beans (at the 10 per cent level) in CAZ. In contrast, the project's positive impact on ginger income is focused on the CAZ area (at the 1 per cent level). Distance from the forest moderates the project's impact on ginger income (at the 10 per cent level).

161. While the FSI shows no difference by subgroup, we can observe how, within the vulnerability index, the project's impact on the sensitivity index is driven by women-headed households (at the 5 per cent level). We also observe how distance from the forest moderates the impact of the intervention on the sensitivity index (which is also the case for the adaptive capacity index). However, the magnitude of these differences is marginal.

162. Turning to the mitigation indicators, we observe that the impact on the importance of the COBA in helping manage forests and natural resources is concentrated in the CAZ area (at the 10 per cent level). The initial level of vulnerability moderates this impact (at the 10 per cent level). Furthermore, the impact on the likelihood of deriving income from non-environmentally sustainable activities in the winter is being driven by male-headed households (at the 10 per cent level) and for households closer to forests (at the 10 per cent level).

V. DISCUSSION

163. The structure of this section follows the evaluation questions described above. This section summarizes the key impacts of the SLEM interventions at midline and interprets these results.

164. Regarding the proportion of households conducting farm livelihood strategies, as detailed in evaluation question one, the reported increase aligns with project expectations and implementation. We find an increase in the proportion of Phase 1 households conducting farm livelihoods of 1 to 3 percentage points in the wet season and 2 to 3 percentage points in the dry season (both at the 1 per cent level). We also see an increase in the proportion of households conducting off-farm livelihoods of 1 to 5 percentage points in the wet season (at the 1 per cent level).

165. This increase in off-farm activities in the wet season (specifically fishing, harvesting wild forest products, and harvesting timber) deserves attention. These activities are based on collecting natural resources from common pool resources and are often understood as coping mechanisms instead of activities to improve resilience. Indeed, there may be a trade-off between allocating labour resources to off-farm activities and agricultural production in the wet season (in terms of less attention to crop care and maintenance, leading to a reduction in production, yields and sales). Some off-farm activities may also influence deforestation rates.

166. Among the different sources of livelihoods, the project is leading to an increase in the proportion of households engaging in non-farm livelihoods (1 to 9 percentage points) in the wet season (significant at the 1 per cent level), suggesting that Phase 1 households are investing in livelihood strategies outside of agriculture, such as small-scale businesses or services, or possibly public works programmes. Project staff interpreted this finding by suggesting households can use surplus agricultural income to diversify income-generating activities by opening small local shops. This is especially the case during the dry season, which coincides with harvesting when wealthier farmers have enough surplus income to diversify income-generating activities. At the same time, wealthier farmers often hire poorer farmers to work in the forest to collect forest resources (including for charcoal production) or to work in agriculture. This enables poorer farmers to supplement their incomes and make additional food purchases.

167. The degree to which beneficiary households engage in non-farm strategies can be assessed again at endline. This is because, in terms of climate resilience, non-farm activities may have a different and possibly lagged climate risk profile, reducing or at least delaying the impacts of climate change. It should also be noted that the subgroup analysis highlighted an increase in non-farm livelihoods that appears to be driven by women-headed households in both wet and dry seasons and by households (with household heads of either gender) in COFAV. Descriptive statistics show a greater proportion of women-headed households are engaged in non-farm livelihoods at midline (around 58.5 per cent) compared to that at baseline (around 30.9 per cent). Women-headed households diversifying into non-farm activities possibly presents an area that could be supported through further project activities. However, care is required here as demand for non-farm goods and services may be limited in more remote locations where markets are thinner. The reasons why a greater proportion of households in COFAV are engaging in non-farm activities deserve attention.[86]

[86] While CAZ and COFAV receive the same interventions, they have differential geographical access to markets.

168. The results for evaluation question two show how a greater proportion of Phase 1 households are practising conservation agriculture techniques as a result of the project interventions compared to Phase 3:[87]

- Soil conservation (2 to 13 percentage points at the 1 per cent level)
- Agroforestry (2 to 6 percentage points at 1 per cent level except for DiD RE v4)
- Terracing (1 to 6 percentage points at 1 per cent level)
- Resistant crops (2 to 6 percentage points at the 1 per cent level)
- Off-season rice (5 to 20 percentage points at the 1 per cent level)
- Storage (2 to 9 percentage points at the 1 per cent level except for DiD RE v4)
- Savings groups (4 to 10 percentage points at the 1 per cent level)

169. Four areas deserve some discussion here. First is the considerable uptake of climate resistant crops and savings groups, which can be partially explained by the limited prevalence of these activities at baseline. Second is the lack of significant differences in irrigation and multiple cropping. In terms of irrigation, while we can see a meaningful increase in off-season rice production (see below), we do not see any increase in the use of irrigation (although the subgroup analysis suggests that the adoption is taking place by households further from the forest). This deserves further investigation at endline.

170. Third, the result that Phase 1 households do not show any meaningful increases in multiple cropping is slightly surprising, as is the reduction in the proportion of households conducting pest management practices (-7 to -10 percentage points at the 1 per cent level). These issues also deserve further investigation at endline.

171. Fourth, key subgroups of Phase 1 households are driving the adoption of certain practices. These are outlined in Table V–1 below.

Table V–1. Summary of heterogeneity estimates on the adoption of conservation agriculture practices at midline

	Women HH	Men HH	CAZ	COFAV	With distance[a]	No distance[b]	With Vuln	No vuln
Soil conservation	***		**		**		**	(-) *
Agroforestry			**					
Terracing	*							
Resistant crops		*	**					
Multi-crops			*					
Irrigation					**			
Off-season rice		*	*					
Storage								
Pest management		(-)**		(-)*		(-)**		
Saving groups		*	***			**	(-)**	**

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively, based on the heterogeneity estimates discussed in section IV.C and Appendix 9.

[87] The midline estimates offer a range of impacts based on six different models.

(-) indicates that the estimated impact was negative for this subgroup.
[a] with distance from forest considered; [b] no distance from forest considered.

172. Table V–1 shows that women-headed households and households in CAZ drive the adoption of soil conservation measures. Project staff report that women-headed households adopt soil conservation measures more easily on their smaller plots (with an average of 0.90 hectares) than households led by men (with an average of 2.24 hectares). Table V–1 also shows how distance from the forest and the initial level of vulnerability is moderating the project's impact on the adoption of social conservation measures. In addition, the table shows how women-headed households drive the adoption of terracing. Agroforestry, resistant crops, multi-cropping, off-season rice and savings groups are all driven by households in CAZ, with households headed by men driving the adoption of resistant crops, off-season rice and savings groups (with this latter activity moderated by initial levels of vulnerability and distance to the forest). The reduction of the use of pest management is driven by households in COFAV, which are closer to the forest and headed by men.

173. The third evaluation question covers the degree to which the project reduced damage following a climate hazard. The lack of statistical significance regarding harvest and livestock losses is unsurprising, considering this is a midline survey. These can be regarded as longer than short-term outcomes covered in the first two evaluation questions. The subsample analysis shows that women-headed households' crop production was more vulnerable to climate hazards following the project intervention (significant at the 10 per cent level). This result is a concern and deserves further exploration at endline.[88]

174. Evaluation question four focuses on changes in agricultural production. This shows that only ginger was significantly affected by the project at midline, with production increasing by 23 to 36 percentage points at the 5 per cent level or lower. As noted earlier, the project initially promoted ginger and later curtailed it due to concerns about its impact on long-term soil fertility. The project promoted a wider range of cash crops that require a number of years before harvesting, including vanilla, cloves and coffee. The endline survey should be able to capture the project's impacts on these cash crops. According to the subgroup, this result is driven by CAZ households (at the 5 per cent level). Surprisingly, we found that the project's impact on livestock production is negative for male-headed households (at the 10 per cent level) and that the project positively impacted women-headed households' livestock sales (significant at the 10 per cent level).[89] The fifth evaluation question shows how some of the estimates suggest a reduction of income from selling beans and an increase in household expenditure, but this could be in a more consistent manner.

175. The sixth evaluation question concerns food security. The impact table shows an improvement in food security status as represented by the CARI index (5 to 17 decimal points at the 5 per cent and 10 per cent levels). This is an important finding. However, it was not reflected in the number of days without food in the last 12 months, which did not show statistical significance. Moreover, the descriptive statistics presented in section IV illustrate how severe food insecurity has worsened since the baseline survey, as has the clear spatial distribution of food insecurity across COFAV and CAZ. The FSI shows no difference by subgroup.

176. The impact table for evaluation question seven on vulnerability does not show statistical significance for all four variables. While these results are not surprising, as the vulnerability index is an indicator that may take multiple years to show change, the aggregation of 'subindices' into a final

[88] It may be the case the limited number of observations of women-headed households reporting damage could affect the confidence in this result.
[89] It is important to note that livestock support was only completed in COFAV with the provision of ducks, hives, and fingerlings.

index using equal weighting may prevent small changes from being reflected within components or the whole index.

177. Evaluation question 11 on the degree of patrolling leading to better protection of forest areas does not show statistical significance for both variables. Nevertheless, final evaluation question 12 shows a reduction in the proportion of households deriving income from non-environmentally sustainable activities of 1 to 3 percentage points in the summer and 4 to 7 percentage points in the winter (significant at the 1 per cent level). Subgroup analysis suggests that the observed reduction in the winter only concerns male-headed households (at the 10 per cent level).

178. Turning back to the ToC for adaptation (see Figure II–1), the results from the midline survey show that Phase 1 households are reporting the implementation of conservation agriculture practices, increased cultivation of one crop, ginger and a diversification of livelihood activities into off-farm and non-farm activities, with the latter across both wet and dry seasons. The degree to which off-farm activities dependent on natural resources are positive adaptations or negative coping strategies is yet to be determined. Importantly, we also observe an improvement in food security.

179. In terms of the mitigation ToC (see Figure II–2), we can see a lower proportion of households that are extracting resources from protected areas. The degree to which the mitigation goals of increased reporting of violations and a decrease in deforestation are not captured by the data from the midline survey.

VI. CHALLENGES AND SHORTCOMINGS

180. The section summarizes the study's shortcomings to learn from some of the evaluation's challenges and how they have been addressed. Section II of the report has detailed some of the challenges associated with the COVID-19 pandemic and has provided a clear set of constraints that influenced programme implementation. In addition, section III.E outlines the challenges encountered through the application of the research design, including accessing households for the second wave of the survey, confidentiality, building rapport with gatekeepers, retaining personnel, insecurity, cultural events, connectivity and broader challenges and associated solutions. This section covers some of the challenges associated with the evaluation design, sample size and power calculations, and measurement issues. We then highlight specific consequences of the COVID-19 pandemic and reflect on the implications of these constraints.

181. Overall, the evaluation design of a clustered randomized phase-in approach has worked well and allowed the generation of a robust set of estimates of the project's effects based on a clean panel data set. The attrition rate of 9.2 per cent was within the buffer factored into the study and is within acceptable limits. Differential attrition across Phase 1 and Phase 3 households has been controlled for in the v4 specification of our three analytical approaches: a main specification of ITT, a DiD estimation using RE, and LATE estimates using an IV regression. The evaluation team has applied the evaluation design carefully and diligently, and the approach is consistent with international best practice.

182. One broader measurement topic that the midline evaluation has raised concerns the composition and calculation of the vulnerability index. Specifically, if the equal weighting to each subcomponent (and indicators therein) could be refined to better reflect the lived circumstances of household respondents. This topic could be examined with further analysis of the data set.

183. The midline survey added several additional questions to the questionnaire, including the ability to estimate the total value of crop, livestock and forest production, income from project-supported crops and the quantity of charcoal produced. In addition, the midline questionnaire requested feedback from respondents on their experience of the COVID-19 pandemic. Here, respondents in both Phase 1 and Phase 3 locations highlighted increases in the prices of materials, limitations on the ability to migrate and move, harm to business, the loss of jobs and loss of friends and family. These responses shed light on the challenges the pandemic led to in CAZ and COFAV.[90]

184. More broadly, the midline data set highlighted how Phase 1 households reported that 97 households (11.6 per cent) received benefits from other project partners, compared to 138 households in Phase 3 (16.8 per cent). These slight differences do not affect the evaluation design meaningfully due to the randomized design and sample size.

185. The midline questionnaire also allowed respondents to offer feedback on the SLEM project. In total, 91 households raised the issue of social concerns coming from the project. While this sounds like a considerable proportion (around 5 per cent of midline respondents), it is important to recognize that these responses focus on three levels. Of these 91 households, most raised concerns at the association level, with only nine raising concerns at the household level and 11 at the community level.

186. The midline questionnaire also included questions that shed some light on the degree of contamination between Phase 1 and Phase 3 households, especially in terms of receiving in-kind

[90] The endline will aim to better understand if decline in sales compared to the baseline could have resulted from lockdown measures. In addition, it will aim to understand any differences in COVID impacts across Phase 1 treatment and Phase 3 control groups.

grants and technical support in sustainable agricultural practices. Specifically, 141 and 55 Phase 3 households reported these two intervention types, respectively.[91] While, at first glance, such contamination may look concerning, within our three analytical models, we already include the calculation of LATE through an IV regression using a Two-Stage Least-Squares (2SLS) framework. These sets of estimates specifically account for any contamination across treatment and control households. As the impact table and following discussion show, this has been fully accounted for already.

[91] Specifically, within CAZ, beans were distributed in August 2022 for four COBA in Phase 3, groundnuts were distributed in November 2022 for two COBA, and rice was distributed in November 2022 in seven COBA. In COFAV, two COBA Miaradia received beans in September 2022, nine COBA received beans in August/September 2022, ground nut were distributed in December 2022 to three COBA. At the same time as receiving these seeds, households also received training.

VII. CONCLUSION

187. The SLEM project aims to increase the resilience of smallholder farmers and reduce carbon emissions by implementing climate-smart agriculture and more sustainable forest management in two landscapes around protected areas, CAZ and COFAV. SLEM directly supports vulnerable smallholder farmers with the tools and inputs needed to adopt sustainable agriculture techniques and strengthen smallholder capacities in climate change mitigation and adaptation, including through community-based organizations and local government.

188. The LORTA programme has evaluated SLEM through a clustered randomized phase-in design that relied on the randomization of the order in which each eligible cluster receives programme activities. Outputs and intermediate outcomes from the project have been estimated from a midline survey of 1,654 households conducted in late 2022. The midline had an attrition rate of 9.2 per cent. The estimation of the SLEM midline impacts relied on three primary models: the impacts of belonging to early beneficiary groups, irrespective of the actual reception of SLEM interventions (so-called intention-to-treat effects). We also estimated the project's impacts on actual beneficiaries (specifically, Local Average Treatment Effects). Furthermore, we used the panel data to conduct in Difference-in-Differences estimates.

189. For each of these three approaches, we apply two different sets of covariates including key baseline outcomes (specifically logged expenditures and food security) and variables which differed at baseline based on balance tests.

190. We find an increase in the proportion of Phase 1 households conducting farm livelihoods of 1 to 3 percentage points in the wet season and 2 to 3 percentage points in the dry season (both at the 1 per cent level). We also see an increase in the proportion of households conducting non-farm livelihoods (1 to 9 percentage points) in the wet season (significant at the 1 per cent level) and conducting off-farm livelihoods of 1 to 5 percentage points in the wet season (at the 1 per cent level). The increase in non-farm livelihoods appears to be driven by women-headed households.

191. The results from the midline evaluation show how a greater proportion of Phase 1 households are practising the following conservation agriculture techniques as a result of the project interventions compared to Phase 3 control households:

- Soil conservation (2 to 13 percentage points at the 1 per cent level, mainly driven by women-headed households)
- Agroforestry (2 to 6 percentage points at 1 per cent level, confirmed by 5 of 6 sets of estimates)
- Terracing (1 to 6 percentage points at 1 per cent level, mainly driven by women-headed households)
- Resistant crops (2 to 6 percentage points at the 1 per cent level)
- Off-season rice (5 to 20 percentage points at the 1 per cent level)
- Storage (2 to 9 percentage points at the 1 per cent level, confirmed by 5 of 6 sets of estimates)
- Savings groups (4 to 10 percentage points at the 1 per cent level)[92]

192. Regarding agricultural production outcomes, the midline evaluation found that one crop was significantly affected by the project at midline, ginger, with production increasing by 23 to 36 percentage points at the 5 per cent level or lower. [93]

[92] We also find a reduction in the proportion of households practicing pest management strategies (7 to 10 percentage points at the 1 per cent level). Multi-cropping, irrigation and the number of conservation agricultural practices do not show consistent levels of significance.

193. More importantly, the midline evaluation showed an improvement in food security status as represented by the CARI index of 5 to 17 decimal points at the 5 and 10 per cent levels. The CARI index ranges from 1.00 (food secure) to 4.00 (severely food insecure). Concerning forest conservation, the midline evaluation found a reduction in the proportion of households deriving income from non-environmentally sustainable activities of 1 to 3 percentage points in the summer and 4 to 7 percentage points in the winter (significant at the 1 per cent level).

194. Heterogeneity results highlight differential outputs and outcomes across households headed by women, across the two landscapes, as well as across the distance from the forest and the initial levels of vulnerability. When assessing impacts by gender, the midline estimates highlighted that women-headed households drive adoption of soil conservation practices and terracing. In addition, that households headed by men drive adoption of drought-resistant crops, off-season rice, pest management practices, saving groups. The key lesson from the Madagascar midline is the importance of maintaining a strong relationship with the impact evaluation champions across different levels of the stakeholders. An endline survey in 2024 will measure longer-term impacts through DiD with matching using a control group outside the project area that was surveyed at baseline.

[93] As highlighted above, some Phase 1 households initially received ginger as part of the project interventions. However, ginger may damage soil fertility and it was recommended by the project steering committee not to support ginger production.

APPENDICES

Appendix 1. ADAPTATION EVALUATION QUESTIONS, INDICATORS AND SUBINDICATORS

Activity	Question	Indicator	Subindicator
Adaptation	EQ1. Does the implementation of adaptation activities lead to an increase in the number of livelihood strategies used?	EQ1.1. Livelihood diversification	Main sources of livelihood in the wet and dry season: EQ1.1.1. Deriving income from other activities than crop farming or livestock in the wet season (binary variable) EQ1.1.2. Deriving income from other activities than crop farming or livestock in the dry season (binary variable)
		EQ1.2. Number of crops and livestock used by the household	The most important crop and animal products: EQ1.2.1. Total number of crops cultivated by the household (continuous variable, only available at midline) EQ1.2.2. Adoption of any crop promoted by the project (the list of crops differs per COBA, binary variable) EQ1.2.3. Number of different types of livestock owned/herded (continuous variable)
	EQ2. Does the implementation of adaptation activities lead to an increase in the number of conservation agriculture practices implemented?	EQ2.1. Implementation of conservation agriculture practices	EQ2.1.1. Used any agriculture practice (among a given list) to reduce risks related to the impacts of climatic shocks (binary variable) EQ2.1.2. Adoption of agroforestry (binary variable)
		EQ2.2. Number of conservation agriculture practices used by farmers	EQ2.2.1. Number of practices mentioned (continuous variable)
	EQ3. Does the implementation of adaptation activities lead to a reduction in damages to livelihood products resulting from climate hazards?	EQ3.1. Damages in agricultural, forest and livestock products following climate hazards	Impact of climate-related hazards on crops, livestock, forest and trees: EQ3.1.1. Percentage of harvest decrease due to any shock (continuous variable) EQ3.1.2. Percentage of harvest loss of forest products due to any shock (continuous variable) EQ3.1.3. Percentage of animals dead due to any shock (continuous variable) EQ3.1.4. Percentage of harvest decrease due to cyclones (continuous variable) EQ3.1.5. Percentage of harvest loss of forest products due to cyclone (continuous variable) EQ3.1.6. Percentage of animals dead due to cyclones (continuous variable)

ACTIVITY	QUESTION	INDICATOR	SUBINDICATOR
			EQ3.1.7. Percentage of harvest decrease due to floods (continuous variable) EQ3.1.8. Percentage of harvest loss of forest products due to floods (continuous variable) EQ3.1.9. Percentage of animals dead due to floods (continuous variable)
	EQ4. Does the implementation of adaptation activities lead to an increase in agricultural (crops and livestock) production?	EQ4.1. Quantities produced of three main crops, animals, forests/tree products	The total production in the last 12 months for the three most important crops, livestock and domestic animals, forest and tree products: EQ4.1.1. Quantity of rice harvested (continuous variable) EQ4.1.2. Quantity of cassava harvested (continuous variable) EQ4.1.3. Quantity of sweet potatoes harvested (continuous variable) EQ4.1.4. Quantity of beans harvested (continuous variable) EQ4.1.5. Quantity of banana harvested (continuous variable) EQ4.1.6. Total value of crop production EQ4.1.7. Rice yields EQ4.1.8. Cassava yields EQ4.1.9. Sweet potatoes yields EQ4.1.10. Beans yields EQ4.1.11. Banana yields EQ4.1.12. Number of TLU EQ4.1.13. Total value of livestock production EQ4.1.14. Total value of harvested forest products
		EQ4.2. Share of the agricultural production not used for household consumption	The total production in the last 12 months which is used for production and selling: EQ4.2.1. Share of crop production that was sold (continuous variable) EQ4.2.2. Share of crop production that is stored (continuous variable) EQ4.2.3. Share of crop production that was lost (continuous variable) EQ4.2.4. Share of livestock production that was sold (continuous variable) EQ4.2.5. Share of livestock production that was sold (continuous variable) EQ4.2.6. Share of livestock production that is stored (continuous variable) EQ4.2.7. Share of livestock production that was lost (continuous variable) EQ4.2.8. Share of forest product harvest that was sold (continuous variable)

ACTIVITY	QUESTION	INDICATOR	SUBINDICATOR
	EQ5. Does the implementation of adaptation activities lead to an increase in income/expenses?	EQ5.1. Household expenditures	EQ5.1.1. Amount spent on different household assets (continuous variable)
		EQ5.2. Income	EQ5.2.1. Total annual household income (continuous variable)
	EQ6. Does the implementation of adaptation activities lead to an increase in food security?	EQ6.1. FSI based on food consumption, food expenditure shares and the number of strategies to cope for a lack of food	EQ6.1.1. Food consumption: number of days the household members eat a list of food items, which include vegetables, fruits, meat, cereals and sugar (continuous variable)
			EQ6.1.2. Food expenditure: purchase of food for domestic/own consumption (continuous variable)
			EQ6.1.3. Number of coping strategies: household reaction due to a lack of food or a lack of money to buy food (continuous variable)
		EQ6.2. Number of days members of the household did not eat three meals a day	EQ6.2.1. Number of days in each month during which the household did not have enough food, three times a day, to feed all members of the household (continuous variable)
	EQ7. Does the implementation of adaptation activities lead to a reduction of households' vulnerability to climate hazards?	EQ7.1. Climate vulnerability index based on exposure, sensitivity and adaptive capacity of farmers	EQ7.1.1. Adaptative capacity of farmers: education level, ability to read, household physical characteristics, household facilities
			EQ7.1.2. Adaptative capacity of farmers: number of household members, source of livelihood, number of crops, livestock and forest products used, total production of crops, livestock and forest products, access to own land
			EQ7.1.3. Adaptative capacity of farmers: total number of responses and practices implemented
			EQ7.1.4. Adaptative capacity of farmers: access to and use of weather forecast services
			EQ7.1.5. Adaptative capacity of farmers: access to and use of information on markets and membership to organizations
			EQ7.1.6. Agricultural, household and communication items owned by the household
		EQ7.2. Strategies used to respond to hazards	EQ7.2.1. Number of strategies used to respond to any hazard on crops (continuous variable) EQ7.2.2. Number of strategies used to respond to the impact of cyclone on crops (continuous variable) EQ7.2.3. Number of strategies used to respond to the impact of floods on crops (continuous

ACTIVITY	QUESTION	INDICATOR	SUBINDICATOR
			variable)
			Descriptive statistics on the type of strategies used to respond to hazards on crops
			EQ7.2.4. Number of strategies used to respond to any hazard on livestock (continuous variable)
			EQ7.2.5. Number of strategies used to respond to the impact of cyclone on livestock (continuous variable)
			EQ7.2.6. Number of strategies used to respond to the impact of floods on livestock (continuous variable)
			Descriptive statistics on the type of strategies used to respond to hazards on livestock (continuous variable)
			EQ7.2.7. Number of strategies used to respond to any hazard on forest products (continuous variable)
			EQ7.2.8. Number of strategies used to respond to the impact of cyclone on forest products (continuous variable)
			EQ7.2.9. Number of strategies used to respond to the impact of floods on forest products (continuous variable)
			Descriptive statistics on the type of strategies used to respond to hazards on forest products
	EQ8. Does the improvement in food security depend on the sustainable management practices implemented on farms?	EQ8.1. FSI based on food consumption, food expenditure shares and the number of strategies to cope for a lack of food (see Appendix 4 for details on its calculation)	Food security index based on food consumption, food expenditure shares and the number of strategies to cope for a lack of food (see Appendix 3 for details on its calculation)
	EQ9. Does reducing climate vulnerability depend on the sustainable management practices implemented on farms?	EQ9.1. Vulnerability index based on exposure, sensitivity and adaptive capacity of farmers (see Appendix 4 for details on its calculation)	Vulnerability index based on exposure, sensitivity and adaptive capacity of farmers (see Appendix 4 for details on its calculation)

Source: LORTA team

Appendix 2. MITIGATION EVALUATION QUESTIONS, INDICATORS AND SUBINDICATORS

Activity	Question	Indicator	Subindicator
Mitigation	EQ10. Do patrollers cover the designated area during patrols? How much of the total protected forest area in the region is not patrolled?	N/A	
	EQ11. Do patrolling interventions lead to better enforced regulations in the forest protected area?	EQ11.1. Law enforcement	EQ11.1.1. Satisfaction with the protection level in the CAZ/COFAV forest corridor (regulations, patrolling, law enforcement, etc.)
			EQ11.1.2. Violations reported to the authorities/COBA
	EQ12. Do patrolling interventions result in a reduction in deforestation?	EQ12.1. Quantity of deforestation	
		EQ12.2. Charcoal consumption	EQ12.2.1. Deriving income from non-environmental sustainable activities (e.g. timber, charcoal) in any season (binary variable) EQ12.2.3. Quantity of charcoal harvested (continuous variable)
	EQ13. Does deforestation increase in other areas outside of the project implementation due to an increase in forest surveillance in the target areas?	Quantity of deforestation	
		Main cause of deforestation	

Source: LORTA team

Appendix 3. FOOD SECURITY INDEX

CI followed a method used by the WFP to assess household food security. The WFP developed a standardized approach for assessing and reporting on household food insecurity in 2012. The WFP Consolidated Approach for Reporting Indicators of Food Security (CARI) helps to develop food security indicators quantitatively, systematically and transparently. In the CARI method, three food security indicators commonly used by WFP are combined into a summary indicator called the FSI. The FSI represents the *overall food security status* of the population of interest (e.g. household, village, region). The household is the smallest unit of analysis in the CARI. Each household is categorized into a food security group from 1-4 (i.e. 1. Food secure 2. Marginally food secure 3. Moderately food insecure 4. Severely food insecure). The WFP uses this index to track the progress and effectiveness of food-related operations and in the scientific literature.[94] In addition, a scientific comparative study that compared different FSIs recommended using the WFP methodology when planning interventions related to long-term chronic food insecurity.

Based on the answers to the household's questionnaire's module on food security, CI calculated the three subindexes that combined formed the CARI FSI. The three subindexes are the food consumption score, the food expenditure share and the livelihood coping strategies categories.

Food consumption score

The food consumption score is an indicator of dietary consumption that includes both quantity and quality considerations. The quantity part of the indicator is calculated using the frequency of consumption (number of days) of eight food groups consumed by a household during the 30 days before the survey. The quality part of the indicator is calculated using the dietary diversity of the household assessed through the number of different food groups consumed over the last 30 days.

Food share of expenditure

The food share of expenditure helps estimate how much of the household budget is used for food. In other words, how significant is the role of food concerning the consumption of other non-food items? The index is based on food expenditure shares, with the most food insecure spending greater than 75 per cent of their budget on food and food secure spending less than 50 per cent.

Livelihood coping strategy

The livelihood coping strategy categories are used to assess how the households meet their basic food needs despite being affected by shocks. It is used to understand the frequency and severity of changes in food consumption of households affected by food shortages. Understanding the household's strategies to adapt to recent climate change impacts provides insights into the difficulty of their situation and their likelihood of meeting future challenges. The interviewed households were asked if any member of their households had to engage in 10 coping strategies because there was not enough food or money to buy food during the past 30 days. Households were asked about four stress strategies, three crisis strategies and three emergency strategies that were categorized according to the severity of the strategies. The 10 strategies were selected according to the CARI methodology and based on known strategies used in the region from previous household surveys. The higher the value of the index, the higher the degree of food insecurity.

Calculation of the FSI

94 Isaura, Chen and Yang (2018).

Applying the CARI methodology, the FSI is calculated using the averages of the three subindexes with more weight to the indicator of food consumption compared to those of food expenditure and coping strategies (food security index= AVERAGE(food consumption, AVERAGE(food expenditure, food coping strategies))).

Appendix 4. CLIMATE CHANGE VULNERABILITY INDEX

To assess the climate change vulnerability of the target population (smallholder farmers located in the target area of the GCF Madagascar project), CI developed a climate change vulnerability index that builds on data collected in the household survey. As there is no standardized way to measure climate change vulnerability, CI identified the variables from the household survey that best assess the three components used to assess the vulnerability to climate change: exposure, sensitivity and adaptive capacity.

Exposure of the target population refers to changes in climate or weather (e.g. rainfall changes, temperature changes, changes in sea level, increased incidence of hurricanes and droughts, etc.) that are affecting/will affect the region where the target population lives.

Sensitivity of the target population refers to the impacts that changes in climate or weather cause on the livelihoods of the target population (e.g. by affecting crop production) and/or on the ecosystem services that they rely on (i.e. water, wild food, pest control, ecotourism).

Adaptive capacity of the target population refers to whether they can adjust to the changes in climate and weather and their impacts. Capabilities include human, social, financial, physical, and natural capital, institutions and entitlements, knowledge and information, decision-making and governance.

CI developed composite indices for each one of those components, which were computed based on the questions collected during the baseline. CI then aggregated these subindices into a final climate change vulnerability index for each household. Questions marked with an asterisk below will be repeated after the project interventions are implemented. This will allow the comparison of the vulnerability index and the sensitivity and adaptive capacity before (baseline) and after (endline) project implementation.

Despite the various methods for assigning variable weights, they ultimately become value judgments. Equal weighting is usually selected because it is believed the indicators are all equally important or no agreed-upon alternative weighting scheme exists. For the present analysis, CI proceeded with an equal weighting approach.

Please note that the variables below refer to the data in midline and that the same variables were used to calculate the vulnerability index at baseline.

Calculation of the exposure score

The following variables, assessed through specific questions asked during the household survey, were used to calculate the exposure of each household. All variables were normalized in quartiles: 1-4 (1 = low exposure, 4 = high exposure). The exposure component is the quartile of variable 1. In all cases, a higher number will represent higher exposure.

- **Variable 1**: Question 27. Changes in climate that negatively affected the household: sum of codes

  q27_6_1_unpredictable_rainfall_ml+

  q27_7_1_less_rainfall_ml+

  q27_8_1_droughts_intensity_ml+

  q27_9_1_floods_frequency_ml+

  q27_10_1_floods_intensity_ml+

  q27_11_1_windcyclones_frequency_ml+

q27_12_1_windcyclone_intensity_ml+

q27_13_1_higher_temp_ml+

q27_14_1_hailfrequency_ml+

q27_15_1_frost_frequency__ml

Calculation of the sensitivity score

The following variables, assessed through specific questions asked during the household survey, were used to calculate the sensitivity of each household. All variables were normalized into quartiles and then ranked from 1-4 (1=low sensitivity, 4= high sensitivity). The sensitivity index is the average of the ranked variables 2-4. In all cases, a higher number will represent higher sensitivity.

- **Variable 2**: Question 29. House and assets damaged: sum of the codes (0-3)

House and assets:

q29_1_1_damage_cyclone_house_ml+

q29_1_2_damage_drought_house_ml+

q29_1_3_damage_hail_house_ml+

q29_1_4_damage_frost_house_ml+

q29_1_5_damage_flood_house_ml1_1

q29_2_1_damage_cyclone_assets_ml+

q29_2_2_damage_drought_assets_ml+

q29_2_3_damage_hail_assets_ml+

q29_2_4_damage_frost_assets_ml+

q29_2_5_damage_flood_assets_ml

- **Variable 3**: Question 29. Sum of decrease in the top product produced in the winter OR in the summer

If crop is the top one in the winter or in the summer:

q29_4_1_damage_cyclone_crop_top1_ml+

q29_4_2_damage_drought_crop_top1_ml+

q29_4_3_damage_hail_crop_top1_ml+

q29_4_4_damage_frost_crop_top_1_ml+

q29_4_5_damage_flood_crop_top1_ml+

If forest product is top 1 in the winter or in the summer:

q29_7_1_damage_cyclone_forest_top1_ml+

q29_7_2_damage_drought_forest_top1_ml+

q29__7_3_damage_hail_forest_top1_ml+

q29_7_4_damage_frost_forest_top1_ml+

q29_7_5_damage_flood_forest_top1_ml+

If animal production is top 1 in the winter or in the summer:

q29_10_1_damage_cyclone_animals_top_1_ml+

q29_10_2_damage_drought_animals_top1_ml+

q29_10_3_damage_hail_animals_top1_ml+

q29_10_4_damage_frost_animals_top1_ml+

q29_10_5_damage_flood_animals_top1_ml+

- **Variable 4**: Question 29. Sum of the days when transportation was unoperational, days without school, days injured/sick and days of recreational activities lost.

Transportation, lack of school, injuries, culture:

q29_3_1_damage_cyclone_transport__ml+

q29_3_2_damage_drought_transport__ml+

q29_3_3_damage_hail_transport__ml+

q29_3_4_damage_frost_transport__ml+

q29_3_5_damage_flood_transport__ml

q29_14_1_damage_cyclone_loss_of_schools_time_ml+
q29_14_2_damage_drought__lack_of_schools_time_ml+
q29_14_3_damage_hail__lack_of_schools_time_ml+
q29_14_4_damage_frost_lack_of__schools_time_ml+
q29_14_5_damage_flood_lack_of__schools_time_ml

q29_13_1_damage_cyclone_injuries_ml+

q29_13_2_damage_drougth_injuries_ml+

q29_13_3_damage_hail_injuries_ml+

q29_13_4damage_frost_injuries_ml+

q29_13_5damage_flood_injuries_ml

q29_15_1_damage_cyclone_culture_ml+

q29_15_2_damage_drought_culture_ml+

q29_15_3_damage_hail_culture_ml+

q29_15_4_damage_frost_culture_ml+

q29_15_5_damage_flood_culture_ml

Calculation of the adaptive capacity score

The following variables, assessed through specific questions asked during the household survey, were used to calculate the adaptive capacity of each household. All variables were categorized in quartiles and then ranked from 1 to 4 (1 = high adaptive capacity, 4 = low adaptive capacity). The adaptive capacity index is the average of the ranked variables below. In all cases, a higher number will represent higher adaptive capacity. However, the ranking will be inverted for calculating the vulnerability index, as lower adaptive capacity leads to higher vulnerability. Therefore, a high number in the adaptive capacity index means a low adaptive capacity.

- **Variable 5**: Question (baseline). Household member: Ratio total adults/total members.

  q12_3_adults_hh_ml/q12_1tot_members_hh_ml

- **Variable 6:** Question 14 (baseline). Highest education level of the HH head: code as is in the survey.

Highest between q11_educationlevel_ml and q14_highest_educ_ml

- **Variable 7**: Question 13 (baseline). Kids at school: ration kids at school/total kids (6-12 years old) in the HH

  If no kids, replace those households by 1 before calculating the quartile

  q13_child_ gotoschool_ml/ q12_5_children_hh_ml

- **Variable 8**: Question 19 (baseline). Household physical characteristics: sum of codes; household facilities: sum of codes

  q19_1_rooftype_ml+

  q19_2_walltype_ml+

  q19_3_floortype_ml+

  q19_4_nb_rooms_ml

  q20_1_electricity_ml+

  q20_2_water_ml+

  q20_3_toilet_ml+

  q20_4_1_cooking_1_ml+

  q20_4_2cooking_2_ml
- **Variable 9**: Question 21 (baseline). Number of livelihoods in the wet season: 1=only 1, 2=only 2, 3 = all 3.

  q21_1_primary_summer_ml

  q21_2_secondary_summer_ml

  q21_3_tertiary_summer_ml
- **Variable 10**: Question 22 (baseline). Number of livelihoods in the dry season: 1=only 1, 2=only 2, 3=all 3.

  q22_1_primary_winter_ml

  q22_2_secondary_winter_ml

  q22_3_tertiary_winter_ml
- **Variable 11**: Question 23 (baseline). Number of crops, livestock and forest products used: sum of the cells with numbers

  q23_1_1_croptop1_ml

  q23_1_2_croptop2_ml

  q23_1_3_croptop3_ml

  q23_2_1_animals_top1_ml

  q23_2_2_animals_top2_ml

  q23_2_3_animal_stop3_ml

  q23_3_1forest_product_top1_ml

  q23_3_3_forest_product_top2_ml

  q23_3_5_forest_product_top3_ml
- **Variable 12**: Question 24 (baseline). Total production of crops if the crop was the primary product in winter or summer (total production – total consumption)

  q24_1_1_1_crop1_production_ml+

  q24_1_2_1crop2_production_ml+

  q24_1_3_1crop3_production_ml)
- **Variable 13**: Question 24 (baseline). Total production of animals if animal production (fish or livestock) was the primary product in winter or summer (total production – total consumption)

  (q24_2_1_1_animal1_production_ml+

  q24_2_2_1_animal2_production_ml+

q24_2_3_1_animal3_production_ml)

- **Variable 14**: Question 24 (baseline). Total production of forest products if forest product was the primary product in winter or summer (total production – total consumption)

  (q24_3_1_1_forest1_production_ml+

  q24_3_2_1_forest2_production_ml+

  q24_3_3_1_forest3_production_ml)

- **Variable 16**: Questions 33.1, 35.1, 37.1. Responses implemented: Sum of the codes

  q33_1_1_response_soil_conservation__used_ml+

  q33_2_1_response_agroforestry_used_ml+

  q33_3_1_response_terracing_used_ml+

  q33_4_1_response_resistant_crops_ml+

  q33_5_1_response_multi_crops_description__ml+

  q33_6_1_response_irrigation_description_ml+

  q33_7_1_response_off_season_rice_ml+

  q33_8_1_response_storage_ml+

  ady_bibikely_mpanimba_voly_ml+

  q33_10_1_response_saving_groups_ml+

  q35_1_1_response_animal_production_ml+

  q35_2_1_response_fish_farming_ml+

  q35_3_1_response_diversified_livelihoods_ml+

  q37_1_1_response_reduce_forest_degradation_used_response_ml

  q37_3_1_response_improve_market_products_ml

- **Variable 17**: Question 58 (baseline). Sum of code numbers

  q58_1_mobile_phone_ml

  q58_2_radio_ml

  q58_3_television_ml

  q58_4_internet_access__ml

  q58_5_mobile_banking__ml

  q58_6_vhs_reader__ml

  q58_7_amplifier_ml

  q58_8_bed_ml

  q58_9_sewing_machine_ml

  q58_1_generator_groupe_ml

  q58_11_petrol_lamp_ml

  q58_12_solar_panel__ml

  q58_13_improved_cooking_stoves__ml

  q58_14_cleaver_big_knife_ml

  q58_15_machete_ml

  q58_16_plough_charrue_ml

  q58_17_chainsaw_ml

q58_18_storage_room_facilities_ml

q58_19_motor_pump_ml

q58_2_sprayer_ml

q58_21_rice_husker_ml

q58_22_kibota_ml

q58_23_herse_ml

q58_24_watering_canister_ml

q58_25_tractor_or_motoculteur_ml

q58_26_bicycle_ml

q58_27_motorcycle_moped_ml

q58_28_oxcart_ml

q58_29_lorry_4_4_ml

q58_3_other_yes_no_ml

Calculation of the climate change vulnerability index

The final vulnerability index of each household was calculated as the average of the exposure, sensitivity and adaptive capacity rankings. The vulnerability index ranges from 1, indicating a marginally vulnerable household, to 4, indicating an extremely vulnerable household. The vulnerability index is calculated for each household.

Appendix 5. MIDLINE QUESTIONNAIRE

Midline questionnaire includes the following modules:

- Module A aims to collect information about the respondent and household characteristics.
- Module B aims to collect information about household livelihoods, such as main sources of livelihoods and income, main products that provide livelihoods and income for the household, total production per year and land tenure.
- Module D aims to identify the drivers of change that are impacting farmers' livelihoods (asked for COBA Phasis 1 and Phasis 2)
- Module E focuses on the impacts of climate change to understand how different hazards, such as strong winds, droughts, hail, frost and flood, may impact households' activities and assets and the food security of household members.
- Module F identifies the actions that farmers are taking to address the impacts of climate change on their livelihoods, assets and food security.
- Module G aims to collect information to measure the food security in the household, following the WFP guidelines.
- Module H collects information to understand the climate awareness of farmers and whether they have received climate information through various channels.
- Module I aims to collect information on forest degradation and deforestation.
- Module J aims to collect information on the types of markets that farmers sell the products to and whether they are conducting activities to improve the value of their products.
- Module K aims to collect information on assets and materials.
- Module L identifies impacts and benefits received from the GCF project.
- Module M identifies impacts of COVID-19 on households.

The baseline questionnaire included 10 modules (A to I, and module L) covering several topics of primary importance for the project:

- Module A aims to collect information about the respondent and household characteristics.
- Module B aims to collect information about household livelihoods, such as main sources of livelihoods and income, main products that provide livelihoods and income for the household, total production per year and land tenure.
- Module C aims to identify what are the drivers of change that are impacting farmers' livelihoods.
- Module D focuses on the impacts of climate change to understand how different hazards, such as strong winds, droughts, hail, frost and flood, may impact households' activities and assets and the food security of household members.
- Module E identifies the actions that farmers are taking to address the impacts of climate change on their livelihoods, assets and food security.
- Module F aims to collect information to measure the food security in the household, following the WFP guidelines.
- Module G collects information to understand the climate awareness of farmers and whether they have received climate information through various channels.
- Module H aims to collect information on forest degradation and deforestation.

- Module I aims to collect information on the types of markets that farmers sell the products to and whether they are conducting activities to improve the value of their products.
- Module L aims to collect information on assets owned by the household and agricultural labour inputs.
- The last part of the questionnaire aims to collect information on farmers' assets and inputs.

However, as mentioned in section III, some information will be collected from the project's monitoring and secondary data (satellite images) sources. Among these sources, the following data will be captured:

- Tons of carbon dioxide equivalent (tCO2eq) reduced or avoided due to sustainable management of forests and conservation and enhancement of forest carbon stocks
- Number of people adopting a wider variety of livelihood strategies that make them more resilient to climate change
- Hectares of critical habitats managed sustainably by local communities within the agricultural landscape (in the project area)
- Hectares of critical habitats restored within the agricultural landscape
- Area of agroforestry projects (ha), silvopastoral systems or other ecosystem-based adaptation strategies established or enhanced
- Forest area under improved management and reduced carbon emissions practices
- Number of hectares restored
- Crop monitoring
- Nurseries and restoration activities
- Training, communication campaign and socio-organization of the COBA
- In-kind distribution
- Gender sensitive indicators tracked for CI

Appendix 6. LOCAL AVERAGE TREATMENT EFFECTS

In this appendix we present LATE impact estimates for v4 of the specification.

Table A - 1. Number of livelihood strategies used

EQ1	IMPACT		CONTROL MEAN	OBSERVATIONS
Farm livelihoods (wet season_ml)	0.03	***	0.98	1194
	(0.02)			
Off-farm livelihoods (wet season_ml)	0.01	***	0.02	1068
	(0.02)			
Non-farm livelihoods (wet season_ml)	0.06	***	0.52	1627
	(0.06)			
Farm livelihoods (dry season_ml)	0.03	***	0.91	1616
	(0.03)			
Off-farm livelihoods (dry season_ml)	-0.02	***	0.04	1450
	(0.02)			
Non-farm livelihoods (dry season_ml)	0.07	***	0.54	1627
	(0.06)			
Total number of crops cultivated by the household	0.11		5.34	1627
	(0.43)			
Tropical livestock unit	0.02		1.57	1627
	(0.39)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the LATE from IV estimation (2SLS or probit), depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 2. Number of conservation agriculture practices implemented

EQ2	IMPACT		CONTROL MEAN	OBSERVATIONS
Response soil conservation used	0.12	***	0.37	1627
	(0.06)			
Response agroforestry used (yes/no)	0.05	**	0.30	1627
	(0.06)			
Response terracing used (yes/no)	0.05	***	0.20	1627
	(0.07)			
Response resistant crops	0.04	***	0.09	1627
	(0.04)			
Response multi-crops description	-0.04		0.43	1627
	(0.06)			

EQ2	IMPACT		CONTROL MEAN	OBSERVATIONS
Response irrigation description	-0.01		0.55	1627
	(0.08)			
Response off-season rice	0.16	***	0.38	1627
	(0.07)			
Response storage	0.08	***	0.22	1627
	(0.07)			
Response pest management	-0.13	***	0.31	1627
	(0.06)			
Response saving groups	0.10	***	0.08	1616
	(0.04)			
Percentage of HH which implement at least one practice	0.02	***	0.89	1627
	(0.03)			
Number of conservation agricultural practices	0.45		2.93	1626
	(0.34)			

Source: LORTA team

Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the LATE from IV estimation (2SLS or probit), depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 3. Reduction in damage following a climate hazard

EQ2	IMPACT	CONTROL MEAN	OBSERVATIONS
Percentage of top crop harvest decrease due to any shock (ml)	-2.94	55.46	1613
	(5.15)		
Percentage of top forest products harvest decrease due to any shock (ml)	-0.35	5.18	783
	(2.67)		
Percentage of top 1 animal dead due to any shock (ml)	0.27	6.58	1459
	(2.01)		

Source: LORTA team

Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the LATE from IV estimation (2SLS or probit), depending on the nature (continuous or binary) of the indicator.
Sampling weights are included and standard errors are clustered at the COBA level.
The control mean represents the mean indicator value within Phase 3 households.

Table A - 4. Increase in agricultural production

EQ4	Impact		Control mean	Observations
Rice production at midline (ish)	0.03		6.20	1627
	(0.14)			
Beans production at midline (ish)	-0.24		1.24	1626
	(0.29)			
Groundnuts production at midline (ish)	0.04		0.43	1627
	(0.25)			
Bambara peas production at midline (ish)	-0.16		0.22	1626
	(0.18)			
Ginger production at midline (ish)	0.23	**	0.09	1627
	(0.11)			
Share of crop production that was sold (ml)	0.53		11.25	1627
	(1.67)			
Share of livestock production that was sold (ml)	-0.50		4.70	1624
	(1.00)			
Share of forest product harvest that was sold(ml)	-0.51		1.18	1620
	(0.84)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the LATE from IV estimation (2SLS or probit), depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 5. Increase in income or expenditure

EQ5	Impact	Control mean	Observations
Income from rice selling (ish)	-1.09	5.06	1560
	(0.89)		
Income from bean selling (ish)	-1.89	6.19	741
	(1.30)		
Income from groundnut selling (ish)	-1.70	6.40	282
	(2.00)		
Income from bambara peas selling (ish)	-0.03	3.48	139
	(1.91)		
Income from ginger selling (ish)	2.07	9.45	91
	(1.73)		
Total annual household income (ish)	-0.14	14.03	1599
	(0.17)		
Household expenditures (ml) (ish)	0.09	14.95	1595
	(0.11)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the LATE from IV estimation (2SLS or probit), depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 6. Increase in food security

EQ6	Impact		Control mean	Observations
CARI at midline	-0.17	*	2.61	1627
	(0.10)			
Number of days without food the last 12 months	2.01		59.33	1624
	(9.17)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the LATE from IV estimation (2SLS or probit), depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 7. Reduction of households' climate vulnerability

EQ7	Impact	Control mean	Observations
Vulnerability index	0.03	2.41	1206
	(0.09)		
Exposure index	-0.06	2.11	1540
	(0.18)		
Sensitivity index	0.02	2.45	1277

EQ7	Impact	Control mean	Observations
	(0.14)		
Adaptive capacity index	-0.02	2.66	1484
	(0.05)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the LATE from IV estimation (2SLS or probit), depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 8. Enforcement of regulations for forest protection

EQ11	Impact	Control mean	Observations
Satisfaction level with the level of forest corridor protection at midline	0.06	2.91	1604
	(0.14)		
Importance of the COBA in helping manage forests and natural resources at midline	0.06	3.71	1589
	(0.23)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the LATE from IV estimation (2SLS or probit), depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 9. Reduction in deforestation

EQ12	Impact		Control mean	Observations
Deriving income from non-environmental sustainable activities summer_ml	-0.03	***	0.06	1616
	(0.02)			
Deriving income from non-environmental sustainable activities winter_ml	-0.07	***	0.13	1616
	(0.04)			
Quantity of charcoal harvested_ml	16.24		1.15	1613
	(19.83)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the LATE from IV estimation (2SLS or probit), depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Appendix 7. DIFFERENCE-IN-DIFFERENCE WITH RANDOM EFFECTS

In this appendix we present DiD impact estimates with RE for v4 of the specification.

Table A - 10. Number of livelihood strategies used

EQ1	Impact		Control mean	Observations
Farm livelihoods (wet season_ml)	0.00	***	0.99	2410
	(0.01)			
Off-farm livelihoods (wet season_ml)	0.01	***	0.02	3278
	(0.01)			
Non-farm livelihoods (wet season_ml)	0.02	***	0.45	3278
	(0.02)			
Farm livelihoods (dry season_ml)	0.02	***	0.96	3256
	(0.01)			
Off-farm livelihoods (dry season_ml)	0.00	***	0.04	3278
	(0.01)			
Non-farm livelihoods (dry season_ml)	0.00		0.43	3278
	(0.02)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 11. Number of conservation agriculture practices implemented

EQ2	Impact		Control mean	Observations
Response soil conservation used	0.02	***	0.41	3278
	(0.02)			
Response agroforestry used (yes/no)	0.00		0.37	3278
	(0.02)			
Response terracing used (yes/no)	0.01	***	0.20	3278
	(0.01)			
Response resistant crops	0.02	***	0.14	3278
	(0.01)			
Response multi-crops description	-0.02	***	0.42	3278
	(0.01)			
Response irrigation description	-0.02		0.62	3278
	(0.02)			
Response off-season rice	0.05	***	0.35	3278

EQ2	Impact		Control mean	Observations
	(0.02)			
Response storage	0.00		0.25	3278
	(0.02)			
Response pest management	-0.07	***	0.40	3278
	(0.02)			
Response saving groups	0.04	***	0.06	3278
	(0.01)			
Percentage of HH which implement at least one practice	-0.02	***	0.92	3278
	(0.01)			
Number of conservation agricultural practices	0.04		3.21	3277
	(0.07)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 12. Reduction in damage following a climate hazard

EQ3	Impact		Control mean	Observations
Percentage of top crop harvest decrease due to any shock (ml)	-1.20		49.88	3263
	(1.21)			
Percentage of top forest products harvest decrease due to any shock (ml)	-2.99	***	9.00	2427
	(0.89)			
Percentage of top 1 animal dead due to any shock (ml)	-0.18		4.78	3110
	(0.58)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 13. Increase in agricultural production

EQ4	Impact		Control mean	Observations
Rice production at midline (ish)	-0.16	**	6.56	3278
	(0.07)			
Beans production at midline (ish)	-0.09		1.30	3277
	(0.07)			
Bambara peas production at midline (ish)	-0.04		0.17	3277

EQ4	Impact		Control mean	Observations
	(0.03)			
Ginger production at midline (ish)	0.24	***	0.05	3278
	(0.05)			
Share of crop production that was sold	2.21	***	13.30	3278
	(0.57)			
Share of livestock production that was sold	-0.14		7.68	3275
	(0.41)			
Share of forest product harvest that was sold	-1.06	***	4.24	3271
	(0.41)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the LATE from IV estimation (2SLS or probit), depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 14. Increase in income or expenditure

EQ5	Impact		Control mean	Observations
Household expenditure(ish)	0.06	**	14.96	3193
	(0.03)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 15. Increase in food security

EQ6	Impact		Control mean	Observations
CARI		**	2.53	3278
Number of days without food in the last 12 months	0.06		29.72	3272
	(0.03)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 16. Reduction of households' climate vulnerability

EQ7	Impact		Control mean	Observations
Vulnerability index	-0.03			2809
	(0.02)			
Exposure index	-0.07			3191
	(0.04)			
Sensitivity index	-0.02		2.53	2901
	(0.03)			
Adaptive capacity index	-0.01		29.72	3111
	(0.01)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 17. Enforcement of regulations for forest protection

EQ11	Impact		Control mean	Observations
Satisfaction level with the level of forest corridor protection at midline	-0.06		3.13	3255
	(0.04)			
Importance of the COBA in helping manage forests and natural resources at midline	0.05		4.06	3240
	(0.05)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Table A - 18. Reduction in deforestation

EQ12	Impact		Control mean	Observations
Income from non-environmental sustainable practices/summer	-0.01	***	0.06	3256
	(0.01)			
Importance of the COBA in helping manage forests and natural resources at midline	-0.04	***	0.09	3256
	(0.01)			

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Impacts represent the marginal effects from OLS or probit regression, depending on the nature (continuous or binary) of the indicator. Sampling weights are included and standard errors are clustered at the COBA level. The control mean represents the mean indicator value within Phase 3 households.

Appendix 8. IMPACT TABLE

In this set of tables, we present the impact coefficients and standard errors for versions 3 and 4 of our main specification (ITT effects), DiD RE and LATE.

Table A - 19. Number of livelihood strategies used

EQ1	Main specification v4		Main specification v3		DiD RE v4		DiD RE v3		LATE v4		LATE v3	
Farm livelihoods (wet season_ml)	0.01	***	0.01	***	0.00	***	0.00	***	0.03	***	0.02	***
	(0.01)		(0.01)		(0.01)		(0.00)		(0.02)		(0.01)	
Off-farm livelihoods (wet season_ml)	0.01	***	0.01	***	0.01	***	0.05	***	0.01	***	0.01	***
	(0.01)		(0.01)		(0.01)		(0.01)		(0.02)		(0.02)	
Non-farm livelihoods (wet season_ml)	0.07	***	0.06	***	0.02	***	0.01	**	0.06	***	0.09	***
	(0.04)		(0.04)		(0.02)		(0.02)		(0.06)		(0.06)	
Farm livelihoods (dry season_ml)	0.02	***	0.02	***	0.02	***	0.02	***	0.03	***	0.02	***
	(0.02)		(0.02)		(0.01)		(0.01)		(0.03)		(0.03)	
Off-farm livelihoods (dry season_ml)	-0.01	***	-0.01	***	0.00	***	0.03	***	-0.02	***	-0.02	***
	(0.01)		(0.01)		(0.01)		(0.01)		(0.02)		(0.02)	
Non-farm livelihoods (dry season_ml)	0.08	***	0.06	***	0.00		-0.01	*	0.07	***	0.10	***
	(0.04)		(0.04)		(0.02)		(0.02)		(0.06)		(0.06)	
Total number of crops cultivated by the household	0.17		0.12						0.11		0.17	
	(0.30)		(0.29)						(0.43)		(0.43)	
Tropical Livestock Unit	0.02		0.01						0.02		0.01	
	(0.26)		(0.25)						(0.39)		(0.38)	

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard errors are indicated in parentheses.

Table A - 20. Number of conservation agriculture practices implemented

EQ2	Main spec. v4		Main spec. v3		DiD RE v4		DiD RE v3		LATE v4		LATE v3	
Soil conservation used	0.09	***	0.08	***	0.02	***	0.05	***	0.12	***	0.13	***
	(0.04)		(0.04)		(0.02)		(0.02)		(0.06)		(0.06)	
Agroforestry used	0.04	***	0.04	***	0.00		0.02	***	0.05	**	0.06	***
	(0.04)		(0.04)		(0.02)		(0.02)		(0.06)		(0.06)	
Terracing used	0.04	***	0.04	***	0.01	***	0.03	***	0.05	***	0.06	***
	(0.05)		(0.05)		(0.01)		(0.01)		(0.07)		(0.07)	
Resistant crops	0.04	***	0.04	***	0.02	***	0.06	***	0.04	***	0.06	***
	(0.03)		(0.02)		(0.01)		(0.01)		(0.04)		(0.04)	
Multi-crops	-0.01		-0.01		-0.02	***	0.04	***	-0.04		-0.02	
	(0.04)		(0.04)		(0.01)		(0.02)		(0.06)		(0.06)	
Irrigation	-0.01		-0.01		-0.02		0.00		-0.01		-0.02	
	(0.05)		(0.05)		(0.02)		(0.02)		(0.08)		(0.08)	
Off-season rice	0.13	***	0.13	***	0.05	***	0.08	***	0.16	***	0.20	***
	(0.05)		(0.05)		(0.02)		(0.02)		(0.07)		(0.07)	
Storage	0.06	***	0.06	***	0.00		0.02	***	0.08	***	0.09	***
	(0.04)		(0.04)		(0.02)		(0.02)		(0.07)		(0.07)	
Pest management	-0.10	***	-0.10	***	-0.07	***	-0.07	***	-0.13	***	-0.14	***
	(0.04)		(0.04)		(0.02)		(0.02)		(0.06)		(0.06)	
Saving groups	0.06	***	0.06	***	0.04	***	0.04	***	0.10	***	0.09	***
	(0.03)		(0.03)		(0.01)		(0.01)		(0.04)		(0.04)	
Percentage of HH implemented > = one practice	0.02	***	0.02	***	-0.02	***	0.00		0.02	***	0.03	***
	(0.02)		(0.02)		(0.01)		(0.01)		(0.03)		(0.03)	

EQ2	Main spec. v4	Main spec. v3	DiD RE v4	DiD RE v3	LATE v4	LATE v3
Number of conservation agricultural practices	0.33	0.30	0.04	0.28 ***	0.45	0.48
	(0.23)	(0.22)	(0.07)	(0.07)	(0.34)	(0.33)

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard errors are indicated in parentheses.

Table A - 21. Reduction in damage following a climate hazard

EQ3	Main spec. v4	Main spec. v3	DiD RE v4	DiD RE v3	LATE v4	LATE v3
% of top crop harvest decrease due to any shock (ml)	-1.98	-1.76	-1.20	0.49	55.46 1613	55.46 1613
	(3.52)	(3.51)	(1.21)	(1.19)		
% of top forest products harvest decrease due to any shock (ml)	-0.95	-0.74	-2.99 ***	-1.55 *	5.18 783	5.18 783
	(1.80)	(1.80)	(0.89)	(0.90)		
% of top 1 animal dead due to any shock (ml)	0.53	0.50	-0.18	0.25	6.58 1459	6.58 1459
	(1.37)	(1.39)	(0.58)	(0.57)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard errors are indicated in parentheses.

Table A - 22. Increase in agricultural production

EQ4	Main spec. v4	Main spec. v3	DiD RE v4	DiD RE v3	LATE v4	LATE v3
Rice production at midline (ish)	0.00	-0.02	-0.16 **	-0.19 ***	0.03	-0.02
	(0.10)	(0.10)	(0.07)	(0.07)	(0.14)	(0.15)
Beans production at midline (ish)	-0.19	-0.21	-0.09	-0.16 **	-0.24	-0.33
	(0.20)	(0.19)	(0.07)	(0.07)	(0.29)	(0.30)
Groundnuts production at midline (ish)	0.03	0.00			0.04	0.00
	(0.16)	(0.16)			(0.25)	(0.24)

EQ4	Main spec. v4	Main spec. v3	DiD RE v4	DiD RE v3	LATE v4	LATE v3
Bambara peas production at midline (ish)	-0.11	-0.13	-0.04	-0.04 *	-0.16	-0.19
	(0.12)	(0.12)	(0.03)	(0.03)	(0.18)	(0.19)
Ginger production at midline (ish)	0.24 **	0.23 **	0.24 ***	0.34 ***	0.23 **	0.36 **
	(0.11)	(0.10)	(0.05)	(0.05)	(0.11)	(0.16)
Total value of crop production (ish)	0.00	-0.01			0.53	0.22
	(0.11)	(0.11)			(1.67)	(1.55)
Total value of livestock production at midline (ish)	-0.37	-0.40			-0.50	-0.37
	(0.40)	(0.40)			(1.00)	(1.06)
Total value of forest production at midline (ish)	0.36	0.34			-0.51	-0.37
	(1.00)	(0.99)			(0.84)	(0.77)
Share of crop production that was sold (ml)	0.36	0.21	2.21 ***	2.48 ***	-0.01	-0.01
	(1.03)	(1.03)	(0.57)	(0.56)	(0.16)	(0.17)
Share of livestock production that was sold (ml)	-0.21	-0.22	-0.14	-0.20	-0.71	-0.60
	(0.70)	(0.71)	(0.41)	(0.40)	(0.59)	(0.60)
Share of forest product harvest that was sold(ml)	-0.20	-0.24	-1.06 ***	-0.59	0.31	0.46
	(0.50)	(0.51)	(0.41)	(0.40)	(1.43)	(1.48)

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard errors are indicated in parentheses.

Table A - 23. Increase in income or expenditure

EQ5	Main spec. v4	Main spec. v3	DiD RE v4	DiD RE v3	LATE v4	LATE v3
Income from rice selling (ish)	-0.75	-0.80			-1.09	-1.19
	(0.66)	(0.61)			(0.89)	(0.92)
Income from bean selling (ish)	-1.70 **	-1.67 **			-1.89	-2.87 **

EQ5	MAIN SPEC. V4		MAIN SPEC. V3		DID RE V4		DID RE V3		LATE V4		LATE V3	
	(0.78)		(0.76)						(1.30)		(1.29)	
Income from groundnut selling (ish)	-1.03		-0.97						-1.70		-1.70	
	(1.05)		(1.14)						(2.00)		(2.00)	
Income from bambara peas selling (ish)	0.43		0.66						-0.03		0.39	
	(1.26)		(1.31)						(1.91)		(1.60)	
Income from ginger selling (ish)	0.82		1.77						2.07		2.18	
	(2.16)		(1.63)						(1.73)		(1.79)	
Total annual household income (ish)	-0.06		-0.07						-0.14		-0.11	
	(0.11)		(0.10)						(0.17)		(0.16)	
Household expenditures (ml) (ish)	0.14	*	0.11		0.06	**	0.09	***	0.09		0.16	
	(0.08)		(0.07)		(0.03)		(0.03)		(0.11)		(0.11)	

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard errors are indicated in parentheses.

Table A - 24. Increase in food security

EQ6	MAIN SPEC. V4		MAIN SPEC. V3		DID RE V4		DID RE V3		LATE V4		LATE V3	
CARI at midline	-0.14	**	-0.12	*	-0.05	**	-0.05	**	-0.17	*	-0.17	*
	(0.07)		(0.06)		(0.02)		(0.02)		(0.10)		(0.10)	
Number of days without food in the last 12 months	2.54		3.22		2.74		4.38	**	2.01		4.91	
	(6.44)		(6.44)		(1.91)		(1.86)		(9.17)		(9.70)	

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard errors are indicated in parentheses.

Table A - 25. Reduction of households' climate vulnerability

EQ7	Main spec. v4	Main spec. v3	DiD RE v4	DiD RE v3	LATE v4	LATE v3
Vulnerability index	0.01	0.01	-0.03	0.00	0.03	0.02
	(0.06)	(0.06)	(0.02)	(0.02)	(0.09)	(0.09)
Exposure index	-0.05	-0.06	-0.07	0.02	-0.06	-0.09
	(0.11)	(0.11)	(0.04)	(0.04)	(0.18)	(0.17)
Sensitivity index	0.01	0.02	-0.02	0.03	0.02	0.02
	(0.10)	(0.10)	(0.03)	(0.03)	(0.14)	(0.15)
Adaptive capacity index	-0.02	-0.02	-0.01	-0.03 **	-0.02	-0.02
	(0.04)	(0.04)	(0.01)	(0.01)	(0.05)	(0.05)

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard errors are indicated in parentheses.

Table A - 26. Enforcement of regulations for forest protection

EQ11	Main spec. v4	Main spec. v3	DiD RE v4	DiD RE v3	LATE v4	LATE v3
Satisfaction level - level of forest corridor protection at midline	0.04	0.03	-0.06	-0.12 ***	0.06	0.05
	(0.09)	(0.09)	(0.04)	(0.04)	(0.14)	(0.14)
Importance of the COBA in managing forests and natural resources at midline	0.08	0.07	0.05	0.04	0.06	0.12
	(0.13)	(0.13)	(0.05)	(0.05)	(0.23)	(0.19)

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard errors are indicated in parentheses.

Table A - 27. Reduction in deforestation

EQ12	MAIN SPEC. V4		MAIN SPEC. V3		DID RE V4		DID RE V3		LATE V4		LATE V3	
Deriving income via non-environmentally sustainable activities - summer (ml)	-0.01	***	-0.02	***	-0.01	***	-0.02	***	-0.03	***	-0.02	***
	(0.01)		(0.01)		(0.01)		(0.01)		(0.02)		(0.02)	
Deriving income via non-environmental sustainable activities - winter (ml)	-0.04	***	-0.04	***	-0.04	***	-0.04	***	-0.07	***	-0.07	***
	(0.02)		(0.02)		(0.01)		(0.01)		(0.04)		(0.04)	
Quantity of charcoal produced (ml)	7.24		5.88						16.24		8.91	
	(11.55)								(19.83)		(17.26)	

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively. Standard errors are indicated in parentheses.

Appendix 9. HETEROGENEITY ANALYSIS

Based on the main specification version 4, in this section, we present the heterogeneity analysis by gender of household head, location in CAZ or COFAV, interaction with distance, as well as initial level of vulnerability. We only present significant results in pairs.

Table A - 28. Number of livelihood strategies used

EQ1	Impact		Observations
Non-farm livelihoods (wet season_ml), when head of household is male	0.11		1654
	(0.07)		
Non-farm livelihoods (wet season_ml), when head of household is female	0.29	**	1654
	(0.13)		
Non-farm livelihoods (dry season_ml), when head of household is male	0.09		1654
	(0.06)		
Non-farm livelihoods (dry season_ml), when head of household is female	0.32	***	1654
	(0.12)		
Non-farm livelihoods (wet season_ml), when residence in CAZ	-0.05		1654
	(0.04)		
Non-farm livelihoods (wet season_ml), when residence in COFAV	0.18	**	1654
	(0.09)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 29. Number of conservation agriculture practices implemented – by gender

EQ2	Impact		Observations
Response soil conservation used, when head of household is male	0.09		1654
	(0.07)		
Response soil conservation used, when head of household is female	0.27	***	1654
Response soil conservation used, when head of household is male	0.09		1654
Response terracing used (yes/no), when head of household is male	0.04		1654
	(0.07)		
Response terracing used (yes/no), when head of household is female	0.18	*	1654
	(0.10)		
Response resistant crops, when head of household is male	0.05	*	1654
	(0.03)		
Response resistant crops, when head of household is female	-0.05		1654
	(0.05)		
Response off-season rice, when head of household is male	0.13	*	1654

EQ2	Impact		Observations
	(0.07)		
Response off-season rice, when head of household is female	0.10		1654
	(0.08)		
Response pest management, when head of household is male	-0.10	**	1654
	(0.05)		
Response pest management, when head of household is female	-0.08		1654
	(0.08)		
Response saving groups, when head of household is male	0.06	*	1654
	(0.03)		
Response saving groups, when head of household is female	0.03		1654
	(0.04)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 30. Number of conservation agriculture practices implemented – by CAZ and COFAV

EQ2	Impact		Observations
Response soil conservation used, when residence in CAZ	0.12	**	1654
	(0.06)		
Response soil conservation used, when residence in COFAV	0.10		1654
	(0.09)		
Response agroforestry used (yes/no), when residence in CAZ	0.17	**	1654
	(0.07)		
Response agroforestry used (yes/no), when residence in COFAV	-0.01		1654
	(0.05)		
Response resistant crops used, when residence in CAZ	0.11	**	1654
	(0.05)		
Response resistant crops used, when residence in COFAV	0.02		1654
	(0.03)		
Response multi-crops description, when residence in CAZ	0.09	*	1654
	(0.05)		
Response multi-crops description, when residence in COFAV	-0.02		1654
	(0.06)		
Response off-season rice, when residence in CAZ	0.17	*	1654
	(0.09)		
Response off-season rice, when residence in COFAV	0.12		1654
	(0.09)		
Response pest management, when residence in CAZ	-0.11		1654
	(0.08)		

EQ2	Impact		Observations
Response pest management, when residence in COFAV	-0.10	*	1654
	(0.06)		
Response saving groups, when residence in CAZ	0.10	***	1654
	(0.03)		
Response saving groups, when residence in COFAV	0.04		1654
	(0.04)		
Number of conservation agricultural practices, when residence in CAZ	0.69	***	1653
	(0.25)		
Number of conservation agricultural practices, when residence in COFAV	0.14		1653
	(0.32)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 31. Number of conservation agriculture practices implemented – interaction with distance

EQ2	Impact		Observations
Response soil conservation used, with interaction with distance	0.00	**	1654
	(0.00)		
Response soil conservation used, without interaction	-0.07		1654
	(0.23)		
Response irrigation description, with interaction with distance	0.00	**	1654
	(0.00)		
Response irrigation description, without interaction	0.22		1654
	(0.23)		
Response pest management, with interaction with distance	0.00		1654
	(0.00)		
Response pest management, without interaction	-0.47	**	1654
	(0.21)		
Response saving groups, with interaction with distance	0.00		1654
	(0.00)		
Response saving groups, without interaction	0.66	**	1654
	(0.29)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 32. Number of conservation agriculture practices implemented – by initial level of vulnerability

EQ2	Impact		Observations
Response resistant crops, with interaction with the initial level of vulnerability	0.60	**	1412
	(0.27)		
Response resistant crops, without interaction with the initial level of vulnerability	-1.26	*	1412
	(0.66)		
Response saving groups, with interaction with the initial level of vulnerability	-0.47	**	1412
	(0.21)		
Response saving groups, without interaction with the initial level of vulnerability	1.45	**	1412
	(0.57)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 33. Reduction in damage following a climate hazard

EQ3	Impact		Observations
Percentage of top crop harvest decrease due to any shock (ml) when head of household is male	-2.92		1640
	(4.58)		
Percentage of top crop harvest decrease due to any shock (ml) when head of household is female	14.53	*	1640
	(7.75)		
Percentage of top crop harvest decrease due to any shock (ml), with interaction with distance	0.10	**	1640
	(0.05)		
Percentage of top crop harvest decrease due to any shock (ml) without interaction	-10.45		1640
	(6.76)		
Percentage of top crop harvest decrease due to any shock (ml) with interaction with the initial level of vulnerability	-12.85	*	1403
	(6.73)		
Percentage of top crop harvest decrease due to any shock (ml) without interaction with the initial level of vulnerability	29.75	*	1403
	(16.66)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 34. Increase in agricultural production – by gender

EQ4	Impact		Observations
Ginger production at midline (ish), when head of household is male	0.24	**	1654
	(0.11)		
Ginger production at midline (ish), when head of household is female	0.22	*	1654
	(0.13)		
Total value of livestock production at midline (ish), when head of household is male	-0.81	*	1650
	(0.48)		
Total value of livestock production at midline (ish), when head of household is female	0.07		1650
	(1.56)		
Share of livestock production that was sold (ml), when head of household is male	-0.42		1651
	(0.93)		
Share of livestock production that was sold (ml), when head of household is female	2.27	*	1651
	(1.24)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 35. Increase in agricultural production – by CAZ and COFAV

EQ4	Impact		Observations
Beans production at midline (ish), when in CAZ	-0.68	*	1653
	(0.37)		
Beans production at midline (ish), when residence in COFAV	0.07		1653
	(0.33)		
Groundnuts production at midline (ish), when residence in CAZ	-0.30	*	1654
	(0.17)		
Groundnuts production at midline (ish), when residence in COFAV	0.17		1654
	(0.31)		
Ginger production at midline (ish), when residence in CAZ	0.81	**	1654
	(0.33)		
Ginger production at midline (ish), when residence in COFAV	0.06		1654
	(0.06)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 36. Increase in agricultural production – interaction with distance

EQ4	Impact		Observations
Ginger production at midline (ish), with interaction with the initial level of vulnerability	0.26	**	1412
	(0.11)		
Ginger production at midline (ish), without interaction with the initial level of vulnerability	-0.38	**	1412
	(0.19)		
Total value of forest production at midline (ish), with interaction with the initial level of vulnerability	-2.65	**	1400
	(1.28)		
Total value of forest production at midline (ish), without interaction with the initial level of vulnerability	7.12	*	1400
	(3.75)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 37. Increase in income or expenditure

EQ5	Impact		Observations
Income from groundnut selling (ish), when head of household is male	-1.25		285
	(1.09)		
Income from groundnut selling (ish), when head of household is female	-5.49	**	285
	(2.11)		
Income from bambara peas selling (ish), when head of household is male	0.69		142
	(1.26)		
Income from bambara peas selling (ish), when head of household is female	-5.00	*	142
	(2.70)		
Income from rice selling (ish), when residence in CAZ	-2.08	**	1586
	(0.94)		
Income from rice selling (ish), when residence in COFAV	-0.17		1586
	(1.01)		
Income from bean selling (ish), when residence in CAZ	-1.66	*	752
	(0.95)		
Income from bean selling (ish), when residence in COFAV	-1.36		752
	(1.11)		
Income from bambara peas selling (ish), when residence in CAZ	3.22	**	142
	(1.57)		
Income from bambara peas selling (ish), when residence in COFAV	0.24		142
	(1.26)		

EQ5	Impact		Observations
Income from ginger selling (ish), when residence in CAZ	9.43	***	91
	(0.70)		
Income from ginger selling (ish), when residence in COFAV	-0.27		91
	(0.99)		
Income from ginger selling (ish), with interaction with distance	-0.02	*	91
	(0.01)		
Income from ginger selling (ish), without interaction	3.08		91
	(3.68)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 38. Increase in food security

EQ6	Impact	Observations
No significant difference		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 39. Reduction of households' climate vulnerability

EQ7	Impact		Observations
Sensitivity index, when head of household is male	0.02		1299
	(0.13)		
Sensitivity index, when head of household is female	0.46	**	1299
	(0.23)		
Sensitivity index, with interaction with distance	0.00	**	1299
	(0.00)		
Sensitivity index, without interaction	-0.22		1299
	(0.19)		
Adaptive capacity index, with interaction with distance	0.00	*	1495
	(0.00)		
Adaptive capacity index, without interaction	0.05		1495
	(0.07)		
Sensitivity index, with interaction with the initial level of vulnerability	-0.24	*	1271
	(0.13)		
Sensitivity index, without interaction with the initial level of vulnerability	0.64	**	1271
	(0.32)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 40. Reduction in deforestation

EQ11	Impact		Observations
Deriving income from non-environmental sustainable activities winter_ml, when head of household is male	-0.04	*	1654
	(0.02)		
Deriving income from non-environmental sustainable activities winter_ml, when head of household is female	-0.03		1654
	(0.05)		
Quantity of charcoal harvested_ml, when head of household is male	4.00		1640
	(15.26)		
Quantity of charcoal harvested_ml, when head of household is female	2.80		1640
	(2.10)		
Deriving income from non-environmental sustainable activities winter_ml, with interaction with distance	0.00		1654
	(0.00)		
Deriving income from non-environmental sustainable activities winter_ml, without interaction	-0.51	*	1654
	(0.27)		
Importance of the COBA in helping manage forests and natural resources at midline, with interaction with initial level of vulnerability	0.37	*	1377
	(0.21)		
Importance of the COBA in helping manage forests and natural resources at midline, without interaction with the initial level of vulnerability	-0.78		1377
	(0.54)		

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

Table A - 41. Enforcement of regulations for forest protection

EQ12	Impact		Observations
Importance of the COBA in helping manage forests and natural resources at midline, when residence in CAZ	0.42	*	1616
	(0.21)		
Importance of the COBA in helping manage forests and natural resources at midline, when residence in COFAV	-0.04		1616

Source: LORTA team
Notes: *, **, and *** represent statistical significance at the 10%, 5%, and 1% level respectively.

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