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

Impact evaluation midline report for FP/SAP 087: Building Livelihood Resilience to Climate Change in the Upper Basin of Guatemala's Highlands

Executive Summary

The project "Building Livelihood Resilience to Climate Change in the Upper Basins of Guatemala's Highlands" has been implemented in the Western Highlands of Guatemala since 2021. Its primary goal is to reduce the impacts of climate change by improving ecosystem and water management within regional watersheds. The intervention aims to strengthen households' resilience and diversification of livelihoods while enhancing their capacity to respond to climate-related events.

Two indices serve as the outcome indicators for the project: the Resilient and Diversified Livelihoods Index and the Responsiveness Index. To rigorously evaluate the intervention's effects, a Difference-in-Difference approach combined with Propensity Score Matching was selected as the core quasi-experimental design.

The original evaluation sample consisted of 24 treatment and 10 comparison micro-watersheds. At midline, 1,256 of the 1,486 baseline households were successfully re-interviewed—739 in the treatment group and 517 in the comparison group. Attrition (15 per cent) was mainly due to non-consent, inability to locate respondents and migration. Because only 12 per cent of treatment households had received any intervention activity by June 2024, the midline provides descriptive results only and does not estimate treatment effects. It is important to mention that the actual data collection methodology does not match the roll-out strategy of the implementation; therefore the endline data collection will be adjusted to make sure to adequately cover the actual implementation plan.

The descriptive analysis indicates the following:

- Resilient and Diversified Livelihoods Index: The index reveals no significant differences between treatment and comparison households. However, vulnerability to climate change has increased since baseline, and crop diversification has declined—likely driven by climate shocks and land sales.
- Responsiveness Index: No differences are observed between groups, although awareness and adoption of conservation practices have increased across the sample. Behavioural change in the use of Early Warning Systems (EWS) remains limited.
- Socioeconomic and livelihood trends: Results show substantial reductions in agricultural sales, land size and land tenure, with migration emerging as a likely driver of these changes. Severe climate shocks—such as prolonged drought during "El Niño" and heavy rains during "La Niña"—have significantly disrupted agricultural production, exacerbating vulnerability.

Overall, while implementation progress has advanced at the project level, the very low exposure of sampled treatment households constrains the feasibility of estimating causal effects at midline. Nonetheless, treatment and comparison households remain broadly comparable, and the foundations for the evaluation design (including common support for matching) are still present. The findings highlight the need for accelerated outreach to intended beneficiaries before endline data collection.

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Abbreviations

ATT	Average Treatment effects on the Treated
COCODE	Local Development Committee
C1	Component 1 (of the project)
C2	Component 2 (of the project)
C3	Component 3 (of the project)
CI	Conditional Independence
CS	Common Support
CSA	Climate-Smart Agriculture
DiD	Difference-in-Difference
DPI	Personal Identification Number (Documento Personal de Identificación)
EbA	Ecosystem-based Adaptation
EWS	Early Warning System
GCF	Green Climate Fund
HFC	High frequency checks
HTTPS	Hypertext Transfer Protocol Secure
IARNA	Institute of Agriculture, Natural Resources and Environment
IEU	Independent Evaluation Unit
INAB	National Forest Institute
INSIVUMEH	National Institute of Seismology, Volcanology, Meteorology and Hydrology
IPWRA	Inverse Probability Weighted Regression Adjustment
IUCN	International Union for Conservation of Nature
KOICA	Korea International Cooperation Agency
LORTA	Learning-Oriented Real-Time Impact Assessment
MAGA	Ministry of Agriculture and Livestock
MARN	Ministry of Environmental and Natural Resources
PAP	Pre-Analysis Plan

pscore	Propensity score
PSM	Propensity Score Matching
ToC	Theory of Change
URL	Universidad Rafael Landívar

I. Executive Summary

The "Building Livelihood Resilience to Climate Change in the Upper Basins of Guatemala's Highlands" project, implemented in the Western Highlands of Guatemala, aims to reduce the impacts of climate change by improving ecosystem and water management in regional watersheds. This initiative is designed to enhance the resilience and diversification of livelihoods while strengthening households' capacities to address climate-related events. In particular, the project includes the following components:

- Component 1: Integrated climate-smart watershed management systems
- Component 2: Community-led watershed management systems promoted through grants
- Component 3: Climate-related information in the form of Early Warning Systems provided to farming households for watershed management

The evaluation measures the effects of activities that are part of each of the components and mainly focuses on two outcome indices: the **Resilient and Diversified Livelihoods Index** and the **Responsiveness Index**. Both indices are calculated using the Anderson index methodology which is a statistical measure used to create a single composite indicator from multiple correlated variables.

To rigorously assess the intervention's impact, a **Difference-in-Difference** approach combined with **propensity score matching** was chosen. The selection of the evaluation sample followed a two-stage cluster sampling approach. First, communities/villages within each of the listed treatment and comparison micro-watersheds were selected randomly. Second, a sample of households was randomly selected using the random walk procedure within each treated or comparison community. The evaluation sample originally included 21 treatment and 14 comparison micro-watersheds, comprising a total of 1,486 households: 758 in the treatment group and 728 in the comparison group. However, significant changes in group allocation occurred between the baseline and midline phases, resulting in an updated sample of 24 treatment and 10 comparison micro-watersheds, now encompassing 888 households in the treatment group and 598 in the comparison group. The decision to change the treatment-comparison composition was made in Q2 2024 by the implementing partner, the International Union for Conservation of Nature, as new funding was allocated to the project and hence, their interest in extending the intervention activities to adjacent areas that were previously designated as a comparison group.

The midline data collection was conducted between October–November 2024 and revisited 1,256 households, 739 from the treatment group and 517 from the comparison group, resulting in an attrition rate of 15 per cent from the baseline. The main reasons for attrition include unreachable households (57 per cent), rejection or unwillingness to be interviewed (21 per cent) or migration to other communities or countries (16 per cent). In addition, the community of La Fe with 24 observations was excluded from the sample altogether as the community leaders rejected the realization of data collection at this place.

Given these circumstances, the feasibility to evaluate impact faces three major challenges: First, changes in the composition of the treatment and comparison groups may affect the evaluation design by reducing the likelihood of finding a sufficiently large common support. Second, the low outreach to treatment beneficiaries (only 12 per cent have been exposed to project activities) impacts engagement and likely affects the overall outcome measurement of the intervention. Third, some households are selling their land due to migration or shifting towards non-agricultural activities. According to the targets announced by the International Union for Conservation of Nature, the aim is to reach the treatment group in its entirety in 2025.

Despite significant reductions in sample size due to allocation changes and attrition, the treatment and comparison households remain highly similar in vulnerabilities, gaps and resilience needs. The first index, which measures economic resilience to climate shocks, shows no significant differences between groups, though vulnerability to climate change has increased and crop diversification has declined, likely due to greater climate shock exposure and land sales. The second index, assessing household and community capacity to respond to climate change, also shows no major differences, but there has been increased awareness and an adoption of conservation practices, though behavioural change in using early warning systems remains limited. Socioeconomic characteristics are generally well-balanced, with slight differences in household composition, property ownership and agricultural practices. A key finding is the reduction in agricultural sales, land size and land tenure, likely driven by migration, as climate-related shocks – such as extreme drought from "El Niño" and heavy rains from "La Niña" – have severely impacted farming activities.

As one of the main assumptions for the matching design is the common support, the midline report includes a short exercise on it. Although it is too soon to fully assess the common support due to low treatment exposure and anticipated attrition, the initial results suggest a strong foundation for comparability, with few notable differences between the groups and significant overlap in the distribution of propensity scores.

II. Context

Guatemala is a lower-middle-income country in Central America, bordering Mexico to the north and west, Belize to the northeast, El Salvador to the southeast and Honduras to the east. Despite its small but constant economic growth in the past decades, the country still suffers from high rates of poverty. As of 2023, approximately 55 per cent of the population lives below the poverty line[1], with extreme poverty disproportionately affecting rural and Indigenous communities[2]. Child malnutrition remains alarmingly high, affecting 46.5 per cent of children under five, with rates exceeding 80 per cent in rural areas[3]. The Western Highlands concentrate the highest values of malnutrition and food insecurity, as Indigenous communities have been victims of social, political and economic marginalization (Lopez-Ridaura et al., 2019, PRISMA 2021).

The population in the Highlands of Guatemala is predominantly Indigenous Mayan with 84 per cent of households identifying as Indigenous)[4] and is composed of various linguistic communities. Although Spanish is the official language, many residents proudly speak their ancestral Mayan tongues, keeping alive a linguistic heritage passed down through generations. This includes diverse linguistic and cultural groups, primarily the K'iche' community, followed by Kaqchikel, Mam and the Spanish community. Despite high population density and limited land availability, agriculture is the cornerstone of the Guatemalan Highlands economy, where farmers grow maize, beans, coffee and a variety of fruits in the rich volcanic soil. Individuals residing in the Highlands are mainly small-scale agricultural subsistence farmers who rely on natural resources for their livelihoods. Most of the smallholder farmers in the region cultivate on less than 0.7 hectares of land (Lopez-Ridaura et al., 2019; LORTA, 2022), making it essential for them to maximize its use for both market sales and household consumption. As a result, it is not surprising that most smallholder farmers continue cultivating “milpa,” which is a traditional, small-scale farming system that is central to the Mayan agriculture and culture, and which typically involves the intercropping of maize (corn), beans and squash. Milpa allows smallholder farmers to produce diverse products on the same land (although the main focus is on maize) and at the same time, becomes fundamental in the nutrition and food security of farmers. In addition to farming, water, food and firewood are essential resources that support the daily sustenance and productive activities of households in the region (PRISMA, 2021).

The population highly depends on agricultural activities, mainly at the subsistence level, and therefore, the heavy reliance on natural resources for income and food security renders these households highly vulnerable to climate shocks, including droughts, frosts and floods. Unsustainable agricultural practices such as deforestation, land degradation and slash-and-burn subsistence agriculture, intensify the vulnerability of these households.[5] In recent decades, as socioenvironmental vulnerability has intensified, patterns of human mobility have diversified – particularly migration to the United States, which has become both a coping mechanism and a key driver of socioeconomic activity in the territory through remittances (PRISMA, 2021). For instance, according to a study by Lopez-Ridaura et al., (2019), which investigates food security in more than 4,000 households in the Western Highlands of Guatemala, over half of the households (52 per cent) in the study, agricultural production fell short of meeting the family’s caloric needs, making it necessary for farmers to seek additional sources of food or income (e.g., remittances). The Highlands of Guatemala have altitudes between 1,800 and 3,300 meters above sea level, with average annual minimum and maximum temperatures between 10°C and 18°C and an average value of 15°C. The rainy season happens usually from May to October, and the dry season is from November to April, which means that planting usually takes place before the rainy season starts. In the Western Highlands, two main conditions severely harm the environment and the livelihoods and food security of people. The first is

[1] World Bank, The World Bank In Guatemala: https://www.worldbank.org/en/country/guatemala/overview
[2] World Bank, Rural poverty headcount ratio at national poverty lines (per cent of rural population).
[3] FAO, Suite of Food Security Indicators. https://www.wfp.org/countries/guatemala
[4] Based on the baseline survey.
[5] For instance, slash-and-burn decreases soil fertility until the soil becomes infertile and uncultivable, requiring the acquisition of new land which often requires deforestation.

the high levels of deforestation and forest degradation, which have caused soil erosion, alteration of water flows in the watershed, loss of habitat for flora and fauna and, in general, changes in the provision of ecosystem services. The second is the climate variability which has been modifying the rainfall and temperature patterns in the Western Highlands. In some specific years, an excessive level of humidity has been reported, while in others, communities have suffered from droughts (This phenomenon was influenced by "El Niño Southern Oscillation" - ENSO)[6] (Giorgi, 2006; Aguilar et al., 2005). As such, Guatemala has been experiencing periods with extreme drought conditions (the "El Niño" effect), as well as short periods of heavy rain leading to flooding and landslides (the "La Niña" effect) followed or preceded by very dry days, instead of consistent low rain throughout the rainy season. Lower sustained rainfall, combined with extreme temperatures, increases the frequency of fire incidents on farmland, significantly impacting agriculture. Climate uncertainty, coupled with deteriorating ecosystem conditions and high levels of poverty for the population, increases the risks of suffering from damage due to climatic events.[7]

Changes are also reflected in the Highlands' average dry and wet days, such as drier days followed by a few days with higher rainfall intensity (IUCN, 2021). Sadly, the climate variability has worsened in recent years. For instance, between November 2023 and January 2024, the "El Niño" phenomenon reached its peak and the transition towards "La Niña" took longer, only starting after the second half of the year, which naturally affected the planting cycle. The main threats derived from variability and climate change in the project areas were identified as follows:

- **Increase in the intensity of precipitation**: Precipitation causes natural hazards of a geomorphological nature, such as surface erosion, mass movements, river floods and changes in the channels and alluvial plains, which trigger disasters that affect populations, housing and infrastructure.
- **Change in the duration of dry periods**: Fewer consecutive days with rain are recorded, which are interrupted by longer dry periods. It does not necessarily rain less, but the rain is more intense and lasts fewer days.
- **Increase in temperature**: The temperature increase occurs both during the day and at night, which represents a greater demand for evapotranspiration and, as a result, an increase in water demand.
- **Increase in frosts**: Cold periods can be more intense and, in some cases, more frequent both during the day and at night.

Guatemala's susceptibility to climate change is intensified by its geographical location in a region frequently affected by extreme weather events, such as hurricanes and tropical storms. For instance, Hurricanes Eta and Iota in 2020 inflicted considerable damage on infrastructure and agriculture across Guatemala's Highland regions. The country is ranked among the top ten globally most vulnerable to climate change-related risks (World Bank Group & GFDRR Climate Change Team, 2020). This predicament is further exacerbated by rapid deforestation, with Guatemala losing about 1 per cent of its forest cover annually, which degrades soil quality and diminishes water retention capacity (IUCN, 2021).

In response to these pressing challenges, Guatemala has enacted a National Climate Change Policy and established one of the world's pioneering climate laws: the Framework Law on Climate Change (Decree 7-2013). This law created a National Climate Change Council tasked with implementing mitigation strategies in key sectors including agriculture, forestry, energy production, transportation and waste management (Government of Guatemala, 2013). The government has committed to

[6] The El Niño–Southern Oscillation (ENSO) is a climate phenomenon that affects global weather patterns due to changes in ocean temperatures and atmospheric pressure over the Pacific Ocean.

[7] Internal documents (Funding Proposal FP087).

reducing greenhouse gas emissions by 11.2 per cent by 2030 using domestic resources, with the potential to achieve up to a 22.6 per cent reduction with international support (UNFCCC, 2020).

Given this context, tackling both environmental degradation and social inequities – particularly among Indigenous populations – is essential for building resilience to climate change. Local producers must adopt climate-smart agricultural practices and access timely climate information to better adapt to the region's shifting conditions. In response, the "Building Livelihood Resilience to Climate Change in the Upper Basins of Guatemala's Highlands" project aims to mitigate climate change impacts in the Western Highlands by enhancing ecosystem and water management in regional watersheds while strengthening social and institutional capacities to respond to climate events. Since 2020, the project has focused on improving technical assistance, access to reliable climate data, governance and investment in sustainable land-use practices, including agroforestry, silvopastoral systems and forest management.

III. Project (Intervention) Description

The "Building Livelihood Resilience to Climate Change in the Upper Basins of Guatemala's Highlands" project aims to restore 22,500 hectares of agricultural land through sustainable land-use systems that will improve the provision of ecosystem services, primarily linked to the management and conservation of water and soil, as well as watershed management. The land uses to be promoted include agroforestry and silvopastoral systems, commercial forestry plantations, natural forest management systems and restoration-focused forest plantations. The project is expected to directly benefit 132,000 people, with at least 30 per cent being women, placing particular emphasis on the inclusion of single-parent female-led households. The project will also work directly with Mayan Indigenous peoples, of the linguistic communities Kaqchikel, K'iche' and Mam, as well as with rural youth groups.[8]

The project seeks to achieve the following three outputs:

- Component 1 (C1): Integrated climate-smart watershed management systems.
- Component 2 (C2): Community-led watershed management systems promoted through grants.
- Component 3 (C2): Climate-related information (Early Warning System or EWS) provided to farming households for watershed management

The first component aims to "improve territorial management and promote ecosystem restoration to provide goods and services suitable for adaptation (water provision and reduction of soil erosion), providing evidence for public policies" (IUCN 2024, Interim Report). It addresses unsustainable land-use practices through extension worker training, financial incentives (cash transfers) and the development of management plans for prioritized micro-watersheds. The second component aims to "strengthen and increase community participation in ecosystem-based adaptation, with a focus on the effective participation of women, Indigenous peoples and other vulnerable sectors" (IUCN 2024, Interim Report). It offers funding to community-based organisations present in the area to implement actions in response to climate change. The third component aims to "Reduce vulnerability to negative climate events by improving knowledge of hydroclimatic threats and actions to address those threats" (IUCN 2024, Interim Report). In particular, it supports the generation of climate information and the set-up of a culturally adapted EWS to guide decision-making regarding watershed management practices for agriculture, forestry and conservation purposes to target users.

In terms of project implementation, the first component builds on existing institutional structures from the Ministry of Agriculture and Livestock (MAGA) including the Rural Development Learning Centres and agricultural extension workers, municipal forestry offices/environment units and the environmental education decentralised services of the Ministry of Environmental and Natural Resources (MARN), as well as the local forestry extension support of the National Forest Institute (INAB). The second component channels funding from the Green Climate Fund (GCF) and the Korea International Cooperation Agency directly to community-based organisations through a medium and small grants facility, which will be managed by the Guatemalan Foundation for Environment and Natural Resources Conservation. The intervention activities of components 1and 2 are essentially the same, being the source of funding the only difference. The third component, related to the provision of climate information and the implementation of an EWS directed to farming households and communities, is implemented in collaboration with the Institute of Agriculture, Natural Resources and Environment (IARNA), which is part of the University Rafael Landívar (URL).

The impact that is sought in these communities is to improve the resilience and livelihoods of the population, strengthening their capacity for adaptation, as well as reducing their exposure to climate risks through the use and application of tools, information and practices that are either completely or partially climate related. The Accredited Entity for this project is the International

[8] Internal documents (Funding Proposal FP087).

Union for the Conservation of Nature (IUCN), of which the regional and national offices design and monitor the project activities. Additionally, the project will strengthen the technical capacities and infrastructure of governmental bodies – Ministry of Environmental and Natural Resources (MARN), Ministry of Agriculture and Livestock (MAGA), National Forest Institute (INAB) and National Institute of Seismology, Volcanology, Meteorology and Hydrology (INSIVUMEH). For example, equipment will be provided for the operation of an EWS in the Western Highlands, and the technical capacities of INAB will be strengthened to focus the incentive programme on ecological restoration and the provision of ecosystem services related to climate change adaptation.

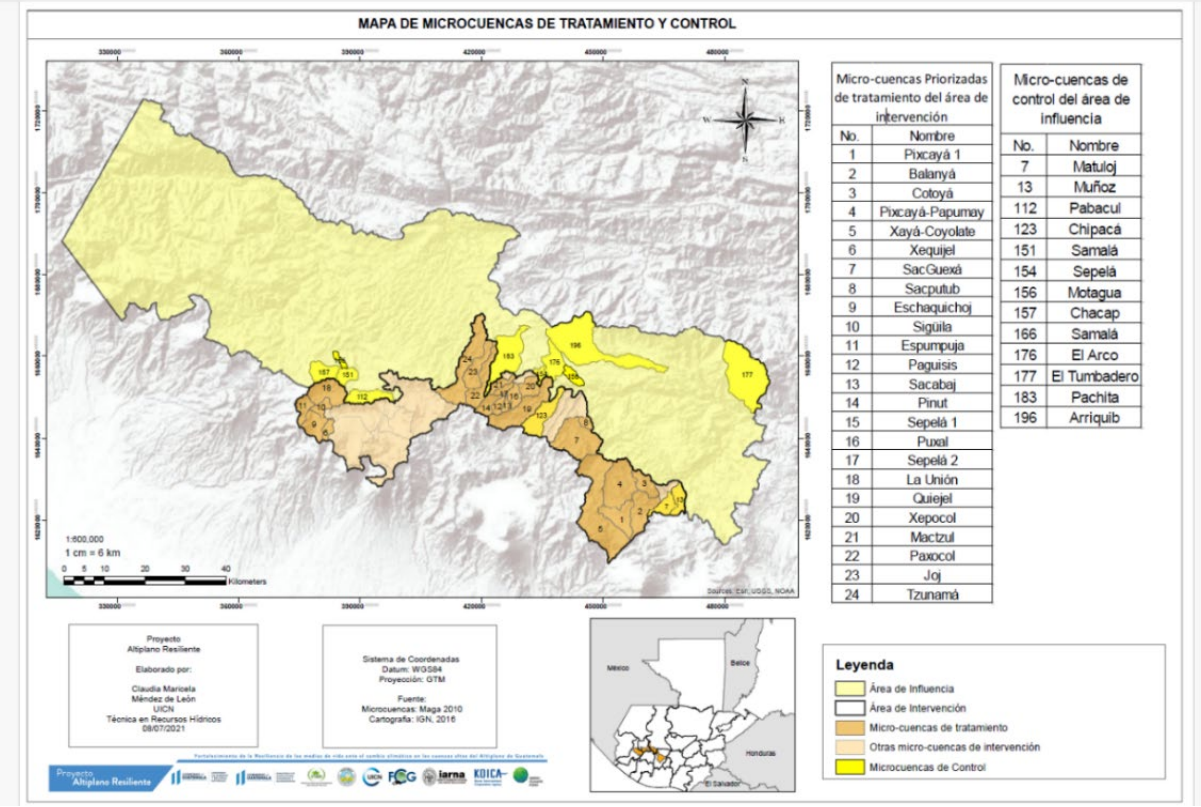
The project area is divided into two parts: the area of influence and the area of intervention. The project's area of influence is in the upper watersheds of the Western Highlands of Guatemala, which make up a total of 7,673 km2 and 334 micro-watersheds (see area in light yellow). The project area of intervention covers a total of 1,468 km^2 and 48 micro-watersheds. The project activities are being implemented in this targeted area. The project actions will focus specifically on the headwaters of four watersheds, Motagua, Coyolate, Samalá and Chixoy, making up what is called the project area of intervention (see Figure 1, area in orange). However, due to financial constraints, the project team selected some of those 48 micro-watersheds and categorised them as "prioritised" given their vulnerability (based on the quantity and quality of the water resource) to be included in the intervention. Hence, the impact evaluation covers the four watersheds but only about half of the micro-watersheds. The project prioritised 24 micro-watersheds (from which 21 were included in the evaluation) that cover 858 km^2 from the intervention area (60 per cent of the intervention area), in which specific watershed management activities will be carried out, such as the formation of micro-watershed committees, governance activities, promotion of forest management plans, among others.

In 2024, the project team identified the opportunity to extend the area of intervention to three other neighbouring micro-watersheds that were previously in the comparison group for the evaluation. Therefore, as of 2024, the sample composition for the evaluation is 24 treatment micro-watersheds and 10 comparison micro-watersheds.

The project is complex in its activities and targets both households and communities of the intervention area. Because of this complexity, the impact evaluation will be conducted on subcomponents C1.1 and C2.1: micro-watershed management and Ecosystem-based Adaptation (EbA) training and component and C3: the EWS. All components target households, which is the unit of analysis for the evaluation.[9] Subcomponents C1.1, C2.1 and component C3 have the potential to affect households in the project area and, in particular, those with farming activities. Furthermore, the activities under these components will be fairly homogenous across the micro-watersheds, which will allow the identification of project outcomes. **The impact evaluation will focus on households that receive any type of training and or cash transfer versus those that are not exposed to treatment.**

[9] In a previous version of this PAP, sub-component C2.1 was not considered part of the evaluation. However, after discussions with the project team in 2024 it was decided to be included as the activities are the same as in C1.1; the only difference being the donor who provides the funding to implement the activities.

Figure 1: Map of treatment and comparison micro-watersheds



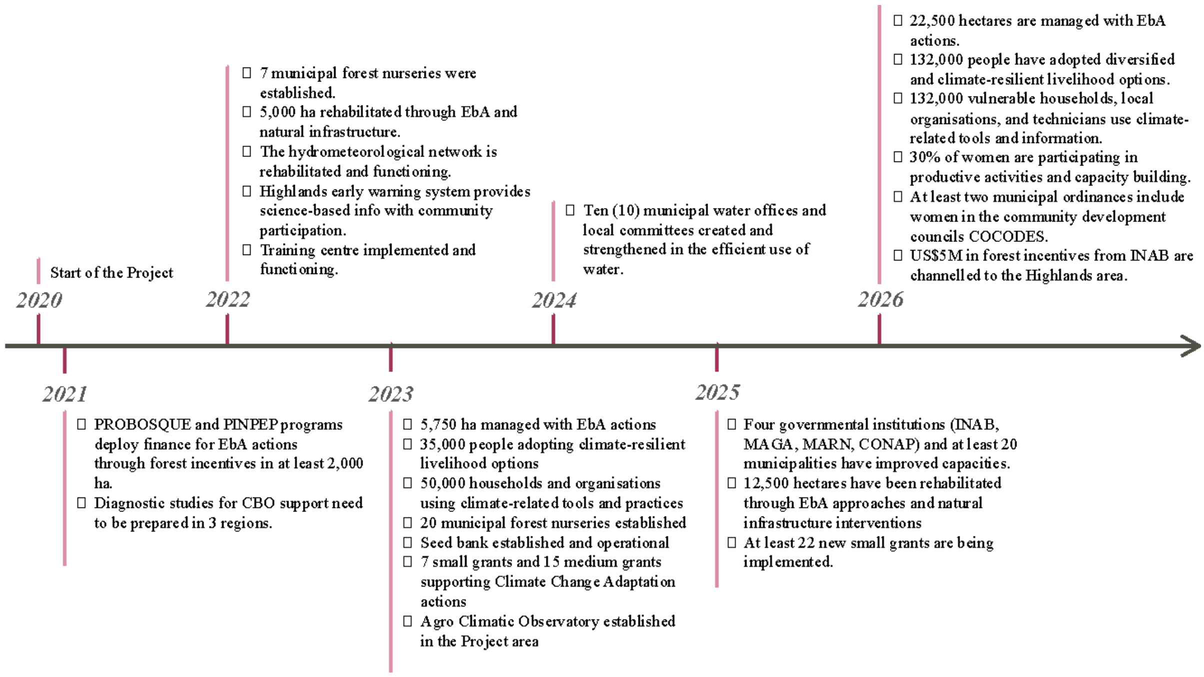
Source: IUCN team

Note: The columns on the left side list all micro-watersheds that are part of the treatment group and the columns on the right side those from the comparison group. The authors would like to remind the reader that micro-watersheds 7 (Matuloj), 13 (Munoz),- and 123 (Chipaca) are being treated. In addition, information from three watersheds in the treatment group was excluded from the evaluation: 12 (Paguisis), 13 (Sacabaj) and 15 (Sepela 1).

The implementation period is seven years, which started on April 8, 2020, the effective date of the Funded Activity Agreement. In 2020, the project started the capacity training of extension workers (INAB, MAGA, etc.) and will continue until 2026. In 2021, the project concentrated its efforts on designing the EWS and developing the micro-watershed development plans. In Q1 2022, farming households started to receive capacity training and early warning information to be transferred to the communities. The main activities and results that are expected over time are presented below in Figure 2. The project is planned to end in April 2027.

As of March 2025, project implementation has made substantial progress toward (and in some cases exceeded) several of the mandatory indicators reported to the Green Climate Fund (GCF). According to the latest monitoring data provided by IUCN, the project has reached 112,226 direct beneficiaries—equivalent to 85 per cent of the target of 132,000—and has already restored or sustainably managed 32,348 hectares of land, surpassing the planned target of 22,500 hectares. In addition, several intermediate results are promising, particularly those related to the provision of ecosystem services for adaptation and improved watershed management.

Figure 2: Timeline for main intervention results and activities

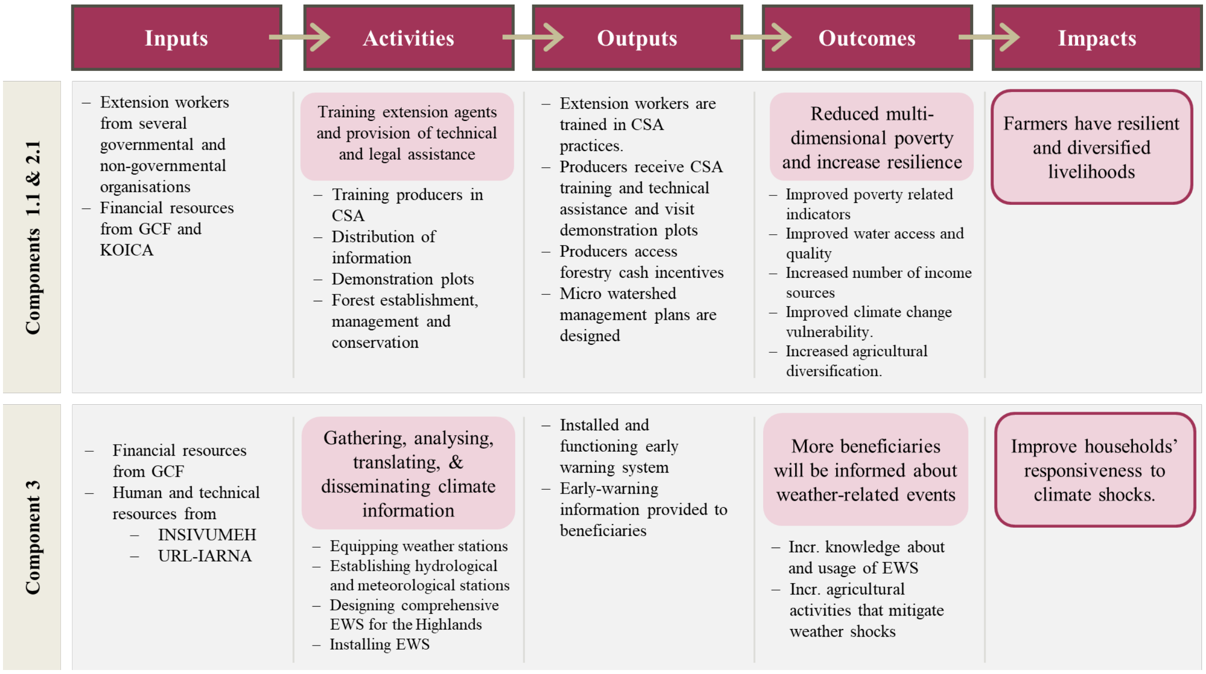


Source: IUCN team

3.1 Theory of Change

The Theory of Change (ToC) provides a framework for understanding how a project's activities lead to desired outcomes and long-term impacts. It identifies the causal pathways, assumptions and contextual factors that link interventions to expected results, ensuring a clear logic for achieving the project's goals. By mapping out these connections, the ToC serves as a foundation for designing, implementing, and evaluating the effectiveness of the project. Figure 3 and Table 1 illustrate the project's theory of change, detailing the inputs, activities and outputs of each component and how they are designed to lead to the desired outcomes and impacts for the beneficiaries. It highlights the logical pathways and connections between project interventions and the intended transformation in the target population, emphasizing how each element contributes to achieving the overall objectives.

Figure 3: Flowchart of the Guatemalan livelihood resilience project ToC



Source: LORTA team

Table 1: ToC for the Guatemalan livelihood resilience project

	Objectives Hierarchy	Indicators	Assumptions
Activities	1.1 and 2.1: Integrated Climate Smart Watershed Management System: Training	- Number of extension workers trained - Budget allocated for training and demonstration plots - Number of demonstration plots established	- Government and implementing agencies prioritize training. - Funds from the IUCN and KOICA are allocated effectively. - Local organizations support resource allocation.
	3: Climate-related information provided for watershed management	- Number of weather and hydrological stations installed/upgraded - Budget allocated for EWS development - EWS designed for the Highlands	- INSIVUMEH and URL-IARNA provide technical support. - Local policies and institutional frameworks support the dissemination and application of EWS knowledge and infrastructure.
Outputs	1.1 and 2.1: Producers and extension workers trained in CSA	- Number of producers trained in CSA practices	- Participants attend the training sessions. - Cash incentives are effective in promoting agroforestry practices. - Management plans align with local needs.

	and EbA practices	- Number of producers accessing forestry incentives - No. of micro-watershed plans that are designed	
	3: Functioning EWS providing early-warning information to beneficiaries	- Percentage of EWS equipment operational - Number of households informed through EWS	- EWS data is accessible and actionable by beneficiaries. - Beneficiaries attend training sessions and have an interest in understanding how the EWS functions. - The agricultural practices promoted to mitigate climate shocks are contextually relevant, feasible and culturally acceptable to the beneficiaries.
Outcome	1.1 and 2.1: Improved farm-level practices and watershed management	- Reduction in multidimensional poverty - Improved water access and quality - Increased agricultural diversity	- Farmers receive training and understand the benefits of diversified agricultural practices. - Beneficiaries have access to new or improved livelihood opportunities that increase income and resources. - Micro-watershed plans are implemented and monitored. - Communities are actively involved in maintaining water systems and managing resources. - Beneficiaries remain engaged with the program long enough to fully acquire and apply the knowledge and practices.
	3: Improved EWS increases the households' responsiveness to climate-related events	- Increased knowledge about EWS and how it works - Application of this knowledge by beneficiaries through agricultural practices that mitigate climate shocks	- Beneficiaries have regular access to EWS information and training materials to build their understanding. - Beneficiaries are able to comprehend and retain the knowledge shared about EWS and agricultural practices. - Beneficiaries remain engaged with the program long enough to fully acquire and apply the knowledge and practices.
Impact	Higher community-level water security, resilient livelihoods	- Increased long-term income stability - Increased adoption of CSA and EbA practices	- Short-term outputs and outcomes result in long-term adaptation and resilience benefits. - Communities maintain EWS and CSA practices after the project concludes.

	and climate adaptation	- Improved climate resilience	

Source: LORTA team

IV. Evaluation Questions and Indicators

The evaluation seeks to answer both main and secondary questions based on the project's Theory of Change (ToC). These questions are aligned with the program's key components and provide a clear framework for assessing the intervention's impacts.

Main Evaluation Questions

- To what extent have farmers in the intervention area achieved more resilient and diversified livelihoods? (C1.1 and C2.1)
- To what extent are farmers in the intervention area less vulnerable to extreme weather events? (C3)

Secondary Evaluation Questions

- To what extent has the intervention changed the multidimensional poverty levels of vulnerable farmers? (C1.1 and C2.1)
- To what extent has the intervention improved access to and quality of water for vulnerable farmers? (C1.1 and C2.1)
- To what extent has the intervention reduced farmers' vulnerability to climate change? (C1.1 and C2.1)
- To what extent has the intervention led to income and crop diversification among beneficiary farmers? (C1.1 and C2.1)
- To what extent has the intervention improved farmers' awareness and knowledge of practices that mitigate climate shocks (e.g., Climate-Smart Agriculture practices)? (C1.1 and C2.1)
- To what extent are farmers better informed about climate change risks and Early Warning Systems (EWS)? (C3)

Evaluation Indices

To address the main evaluation questions, three composite indices were developed:

- **Resilient and Diversified Livelihoods Index** (see Table 2) – This index focuses on economic resilience, examining how well households can withstand and recover from climate shocks. The index incorporates multiple dimensions of vulnerability and resilience (C1.1 and C2.1).
- **Resilience Index Measurement and Analysis -RIMA** (see Table 3) – This index assesses and monitors households' resilience to food insecurity. It provides a comprehensive, data-driven framework for understanding how well households can absorb, adapt to and recover from shocks such as droughts, economic crises or conflict (C1.1 and C2.1).
- **Responsiveness Index** (see Table 4) – This index measures and evaluates the capacity of households and communities to anticipate, respond and adapt to climate-related shocks. It includes both individual and community-level indicators (C3).

These indices are constructed based on prior work by the IUCN team, IEU and established literature. The approach ensures methodological rigor while minimizing noise from multiple hypothesis testing. In addition to these indices, secondary questions will be evaluated using individual indicators for granular insights. Based on the information above, this impact evaluation will test the following hypotheses:

Hypothesis 1: Households receiving training on CSA practices and or cash transfers will have more diversified livelihoods and will be more resilient to climate-related shocks compared to households in the comparison group.

Hypothesis 2: Households receiving training on EWS will have a higher response capacity to climate-related shocks compared to households in the comparison group.

Table 2: Description of the Resilient and Diversified Livelihoods Index

Indicator	Sub-components	Indicator type	Weighting
Multi-dimensional poverty	- Education: Sum of education years completed by female and male head of household - Life quality: Points given to type of roof, floor, water access and quality - Income: Points given based on income and assets (economic strata, household size, TV, motorbike, car, etc.) - Food security: Household classification into 4 categories: not food insecure, low food insecure, medium and high food insecure	Continuous (values between 0-100). Higher values indicate a lower poverty level.	Education 20 points; Life quality 25 points; Income 30 points; Food security 25 points = Total 100 points. Points are given based on the performance of each indicator, for instance, if education = 20, then the household obtains 20 points in this subcomponent. The points attributed for each subcomponent were added and based on the total number the HH was classified in: - Very Poor (0-30 points) - Poor (31-66 points) - Not poor (67-80 points) - Not poor at all (81-100 points)
Water accessibility and quality	Water accessibility	Discrete. Values from 0-2. Higher values indicate better accessibility.	
	Water quality	Discrete. Values from 0-2. Higher values indicate better quality.	
Collecting forest products	Type of products that are collected	Continuous (values between 0-1). Higher values indicate more products are collected.	
Climate change vulnerability	Not affected by a climate shock	Binary. 0 = Lack of money or food was due to climate shock; 1= Lack of money or food was not due to climate shock.	
Agricultural diversification	Diversification index (Simpson's diversity index)	Continuous (values between 0-1). Higher values indicate more diversification.	

Source: IUCN and LORTA teams

Table 3: Description of the RIMA Index

Indicator	Description	Indicator type
Take diversification action	Whether the household has adopted diversification strategies in response to shocks	Binary
Diversification problems	Presence of challenges when attempting to diversify income or production	Binary
Education index (normalized)	Composite index based on education level of household head(s)	Continuous
Will be affected by droughts	Perceived risk of being affected by drought in the near future	Binary
Risk perception	Subjective perception of risk due to climate-related events	Continuous
Asset index	Composite index reflecting household asset ownership	Continuous
Experienced climate change	Household reports experiencing climate-related events in recent years	Binary
Social safety nets	Access to or participation in formal/informal safety net programmes	Binary
Not affected by climate	Whether the household reports no impact from climate events	Binary
Improved latrine	Access to improved sanitation infrastructure (e.g., latrine type)	Binary
Land area (hectares)	Total land area cultivated or owned by the household	Continuous
Father diversified	Whether the father (or head) engaged in diversification historically	Binary
Dietary diversity score	Score reflecting variety of foods consumed in the household	Continuous
Income level	Self-reported income level or income proxy from economic indicators	Continuous
Absorptive capacity	Captures capacity to absorb shocks (e.g., preparedness, buffers)	Continuous
Adaptive capacity	Reflects capacity to adjust and change livelihood strategies	Continuous

Transformative capacity	Long-term institutional and social factors supporting change	Continuous
RCI (all components)	Aggregate index combining all three capacities (absorptive, adaptive, transformative)	Continuous

Source: LORTA team

Table 4: Description of the Responsiveness Index

Indicator	Description	Indicator type
Household perception of climate change risk	Proportion of “yes” responses (out of 10) regarding households’ perceptions/beliefs of potential damage from climate change (crop loss, plagues, less agricultural productivity, etc.)	Continuous. Values from 0-1. Higher values indicate higher perceptions of risk towards climate change.
Household knowledge on responses to climate change effects	Proportion of options mentioned by the participant (out of 13) regarding households’ knowledge on measures/strategies to mitigate effects from climate change (crop diversification, water storage, soil conservation, etc.)	Continuous. Values from 0-1. Higher values indicate more knowledge.
EWS in place at the community	Average of “yes” responses. The average was calculated per community.	Continuous.
Use of EWS information at the community	Average of “yes” responses. The average was calculated per community.	Continuous.

Source: IUCN and LORTA teams

V. Evaluation Strategy and Design

Since implementing a randomized control trial is infeasible, the Difference-in-Difference (DiD) combined with propensity score matching (PSM) was chosen as the most rigorous quasi-experimental approach to measure the intervention effects and test our hypotheses.[10] This design, proposed during Phase I of LORTA, remains valid after the baseline data collection, as households in the treatment and comparison groups can be clearly distinguished.

The DiD technique allows for the causal estimation of treatment effects by assuming that in the absence of the intervention the difference in outcomes between treated and comparison households will remain constant over time.[11] This is known as the "parallel trends" assumption. By construction, the DiD method controls for differences in observed and unobserved time-invariant characteristics between treatment and comparison groups before implementation. Therefore, our preferred specification is the DiD as it will help us to rule out existing differences in time-invariant characteristics that were not captured in the baseline survey or that are unobservable.

In practice, the assumption of **unconditional parallel trends** – which requires that average outcomes for the treatment and control groups would have evolved similarly over time in the absence of the intervention – is often too strong and unlikely to hold. Therefore, we rely instead on the more flexible **conditional parallel trends** assumption. This weaker version of the assumption requires that parallel trends hold only within observable subgroups defined by selected covariates, rather than for the entire sample. By conditioning on these covariates, we acknowledge that treatment and control groups may differ in important ways, and we aim to isolate comparable subpopulations where the assumption is more plausible. Therefore, in addition to the DiD, we will match households in the treatment group with households in the comparison group based on observable baseline characteristics (i.e. before project implementation). The matching approach provides that within the DiD set-up, the most similar units between treatment and comparison groups are compared in order to measure an effect of the project. By ensuring balance in baseline characteristics between the treatment and control group, matching increases the credibility of the parallel trend assumption. Overall, this addition strengthens the quasi-experimental design and hence, makes the analysis more robust.[12]

An important implication of this evaluation design is that it requires oversampling of the comparison group so that a sufficient number of households in that group are effectively matched to treated households. Unfortunately, due to the significant reduction in the comparison sample, oversampling is no longer possible, which creates a risk of not finding suitable matches.

The implementation and evaluation timeline outlines key milestones and activities, spanning from the project's baseline data collection through its endline, to ensure a systematic measurement of outcomes (see Figure 5). Baseline data collection took place from March to June 2021. The process of data

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[10] While there are different matching approaches such as exact matching or Inverse Probability Weighted Regression Adjustment (IPWRA), we decided to use PSM because it collapses all the relevant information from the X matrix (observable baseline characteristics that explain treatment allocation) into a single number - the propensity score (pscores). By grouping households based on their pscores, PSM effectively replicates a randomized experiment with respect to observed covariates, enhancing comparability between the treatment and comparison groups.

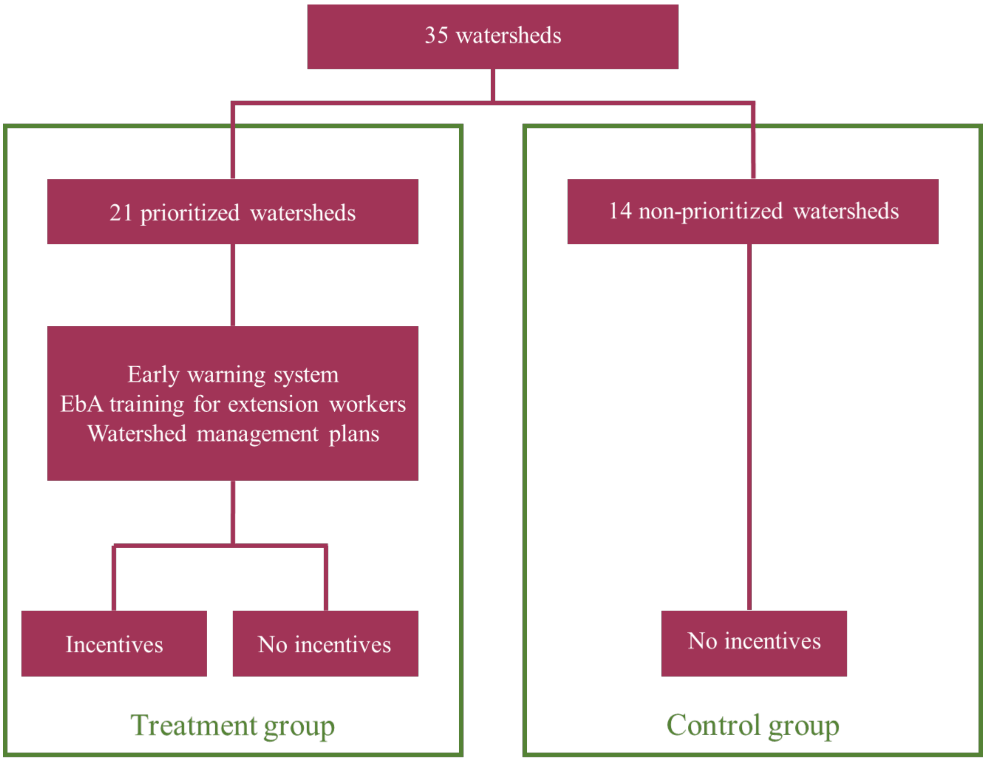
[11] In a nutshell, the DiD works by taking two differences of the outcomes. The first difference, which is the before-and-after comparison of each of the treatment and comparison group outcomes, controls for time-invariant characteristics within the specific group. The second difference, which is the comparison between the treatment and comparison groups, controls for the differences in levels between the treatment and comparison groups before and after the intervention.

[12] The matching technique assumes that the outcome is independent of the selection into treatment when controlling for observable characteristics. This is the conditional independence (CI) condition, and it is usually considered a very strong assumption. When combining the DiD with matching, CI is relaxed because the DiD rules out (unobserved) time-invariant differences between the groups and the CI only needs to hold with respect to changes in outcomes. When this "relaxed" version of the CI holds, it implies that households in the treatment and comparison groups, controlling for observed differences, would have evolved in the same way if they would not have been exposed to treatment. In addition, the matching technique requires that the common support assumption (CS) holds. CS refers to the extent of overlap in key matching variables between the treatment and comparison groups so that matches for the treatment households can be found among the comparison households. The larger number of households that are matched, the more robust the estimates will be.

cleaning, analysis and report writing was completed in December 2021. Although the project started in April 2020, the implementation of field activities related to component C1.1 began in Q2 2021 (which mostly consisted of staff training sessions) and began in Q1 2022 for component C3. In Q1 2022, farmers started receiving capacity training and early warning information. Midline data collection was conducted at the beginning of Q4 2024, and the process of data cleaning, analysis and report writing was completed in February 2025. Endline data collection is planned for the end of 2027 - Q1 2028 (or earlier), approximately seven years after the start of the intervention.

Figure 4 shows the composition as of December 2024 of treatment and comparison groups based on the information provided by the IUCN. In order to capture the different support received by beneficiaries, the evaluation focuses on households that receive training and/or cash incentives versus those that receive no support. The proposed methodology will allow us to identify the effects of the different components (C1.1, C2.1 and C3) on the indices and indicators mentioned in the previous section.[13] If possible, the evaluation could try to disentangle the effects from the trainings to the cash transfers and compare it against the comparison group (multi-treatment comparison), but this assessment will be done towards the end of the project implementation and before endline data collection.

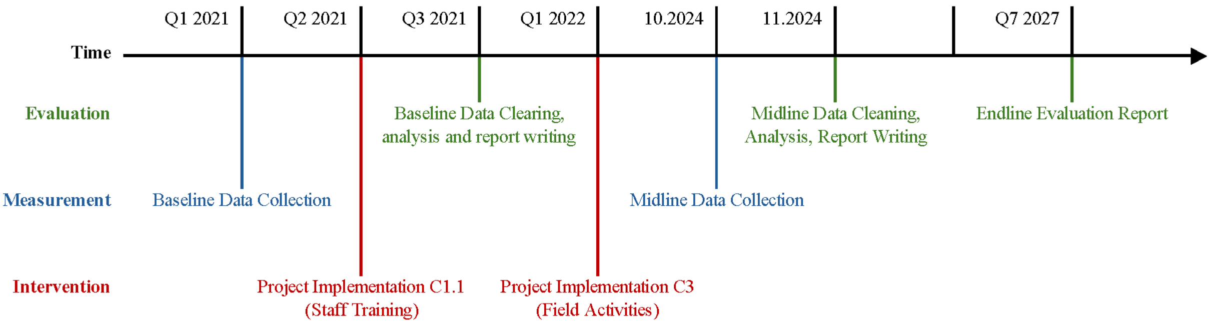
Figure 4: Evaluation Design



Source: LORTA team

[13] In the initial version of the evaluation, households receiving cash incentives were not considered as part of the evaluation. However, per request by IUCN the treatment group further expands as many households seem to be receiving cash incentives. The design will be further assessed before endline data collection.

Figure 5: Timeline for key study events



Source: LORTA team.

Note: Events are organized by evaluation activities (green), measurement activities (blue) and intervention activities (red).

5.1 Description of the Units for Decision Making, the Intervention and for Analysis

Given that all activities that are part of this intervention target households, the unit of analysis for this impact evaluation is the household. The project team particularly targets female and single-headed households because although women's participation in the economy is promoted in Guatemala, the system continues to be patriarchal. This does not facilitate women's participation in different dimensions, such as (local) politics or decisions about land use in their communities. The lack of power in decision-making also threatens women's economic opportunities as women are usually in charge of household chores and providing care for the family. With respect to single households headed by women, the project expects to increase the economic opportunities of women so that they can learn to diversify their livelihood options and become more resilient to climate change. Moreover, the project aims to incorporate women into an economy based on the use of natural resources.

While the sample size is too small to run the DiD and matching specification to estimate heterogenous effects, a descriptive analysis will be conducted upon availability of the dataset.

5.2 Sample Size and Power Calculations

The selection of the evaluation sample followed a two-stage cluster sampling approach. First, communities/villages within each of the treatment and comparison micro-watersheds were selected randomly. Second, a sample of households was randomly selected using the random walk procedure within each treated or comparison community. At the point of baseline data collection, the total sample size was 1,486 households, distributed to 21 treated (758 households) and 13 comparison (728 households) micro-watersheds. However, in June 2024, the project team announced a change in the composition of treatment and comparison watersheds as they saw the opportunity of expanding the area of treatment. As of October 2024, the evaluation sample was composed of 24 treated (888 households) and 10 comparison micro-watersheds (598 households). Yet, further reductions occurred after the midline data collection, conducted between October and November 2024, which **revisited 1,256 of the 1486 households, 739 from the treatment group and 517 from the comparison group, resulting in an attrition rate of 15** per cent **from the baseline.**

As shown in the PAP with a sample size of 1486 households, the Minimum Detectable Effect (MDE) size is 11 per cent for Index 1 (Resilient and Diversified Livelihoods Index) and 19 per cent for Index

2 (Responsiveness Index). The new sample composition poses a risk of capturing a significant effect, particularly due to the reduction in the comparison sample.[14]

5.3 Challenges Encountered with the Research Design and in Data Collection

Regarding the research design, there are two main challenges: confounding and limited alignment between intervention delivery and the intended impact evaluation design. Regarding the first challenge, the main issue lies on the presence of multiple actors in the intervention area implementing similar projects (e.g., PROINNOVA[15] and METAGUA[16]). These overlapping initiatives pose a significant risk of confounding, as they may influence key outcomes like the adoption of CSA practices, agricultural productivity or resilience measures, making it difficult to attribute observed effects solely to the "Building Livelihood Resilience to Climate Change in the Upper Basins of Guatemala's Highlands" project. To address this, it will be essential to map and document concurrent interventions at the community and household levels during endline data collection. While the use of propensity score matching combined with difference-in-differences aims to reduce such biases, collecting detailed exposure data will be critical to further mitigate confounding and strengthen the project attribution to impacts. The second challenge, and probably the most critical, arises from the IUCN's community-based implementation model, which engages beneficiaries through group mechanisms rather than directly reaching out to sampled treatment households. While different discussions have been maintained over the past years, there haven't been any significant changes in the outreach to project beneficiaries.

Regarding data collection specifically, other challenges arise. As mentioned above, a total of 1256 households were interviewed in the midline data collection, which means 230 households did not participate in the midline data collection. This number takes into account the 24 households from the treatment community La Fe, where community leaders from the local development committee (COCODE) requested that the survey cover all 342 households in the village instead of the 24 originally planned. As it was not feasible to accommodate this request, the community chose not to participate in the study. Additionally, 206 households either declined to participate in the midline survey, migrated and could no longer be contacted, passed away or could not be located.

The midline data collection was conducted in two phases. In the first phase, efforts were made to contact the baseline individuals, and 1166 households were reached (78 per cent of the initial total sample). In the second phase, phone calls were integrated in order to reach as many people as possible from the remaining sample. As a result, an additional 90 households were interviewed (85 per cent of the initial total sample).[17] As the attrition level is below 30 per cent, we do not consider the need to change the evaluation design. However, these reductions in total sample size, along with changes in the allocation between treatment and comparison micro-watersheds – in a reduction of the number of

[14] Usually, researchers set the MDE at 10 per cent, which is a rule of thumb. An MDE of 10 per cent means the evaluation is powered to detect a 10 per cent (or more) increase in outcomes due to the pathways programme. If the effect of the programme is lower than 10 per cent (e.g.,7 per cent increase), the conclusion would be that even though beneficiaries experienced some improvements in resilience, the programme had no detectable effect.

[15] https://www.proinnovaguatemala.org/noticias/llevar-prosperidad-al-altiplano-occidental-de-guatemala-si-es-posible/

[16] https://www.marn.gob.gt/proyecto-gestion-ambiental-integral-de-la-cuenca-del-rio-motagua/

[17] The "Phase 2" data collection was conducted with six enumerators paid by IUCN. This second phase aimed to reach out to the remaining treatment group (roughly 150 households) and to some comparison households that could not be reached. As a large part of the remaining households migrated or could not be located, the team of IUCN and local partners identified 103 treatment households and 63 comparison households which were visited during 8 days after the Phase 1 of midline data collection. IUCN coordinated the transportation of the enumerators and provided on-site support through a technical staff member. This technical staff worked to facilitate access to the communities and households as effectively as possible.

households in the treatment group (from 888 to 739) and the comparison group (from 598 to 517) – pose a significant risk to the feasibility of conducting an impact evaluation with the current dataset.

The following sub-sections describe the primary and secondary data sources used during the midline analysis, as well as the fieldwork activities, training of enumerators, data quality monitoring and challenges faced during data collection. The data presented in this midline report is mostly derived from the midline household survey which took place between October and November 2024. Treatment exposure was calculated based on the project's monitoring data, which is constantly updated by the project team and partner organizations.

The midline questionnaire is slightly different from the baseline questionnaire in that it does not include questions related to COVID-19, nor ethnicity, language spoken, linguistic community, ownership of land or members with disabilities. The questions were removed in order to make the survey slightly shorter and to avoid duplicated information from the baseline. The consent form in the midline study was extended with the purpose of providing more information about the study and to avoid potential non-consent. Two questions related to food security and another on the use of measures to mitigate the impacts of climate change were added.

5.3.1. Project monitoring data

In June 2024, the implementing partner IUCN provided the LORTA team with a compiled monitoring dataset. It was extracted from the Smartsheet platform, which the IUCN developed to manage and track each component of the project's implementation. The dataset included participants' basic information such as ID, name, location and activities received. Given this additional input, we undertook the complex task of merging implementation data with baseline data, a process complicated by the absence of unique identifiers and the prevalence of duplicated names.

To ensure that the data was ready for analysis, several meticulous steps were undertaken during the revision process. First, we focused on data preparation, adjusting the formatting to make the dataset compatible with Stata for further processing. This was followed by a thorough data cleaning phase to address inconsistencies and ensure accuracy. We then worked on identifying the activities relevant to the evaluation, excluding meetings and events that were not part of the intervention's scope. Next, the research team matched beneficiaries by linking monitoring data with baseline data using the IDs, names and phone numbers. Given the high number of duplicated names and the absence of ID numbers and phone numbers, unmatched cases were reviewed individually with the IUCN to ensure proper alignment.

Additionally, the team carefully revised the micro-watershed and village information to confirm the geographic accuracy of the records. This process also involved discussions about changes in the allocation of treatment and comparison micro-watersheds, requiring adaptations to the baseline database to reflect these updates accurately. Finally, throughout this process, general coordination meetings were held to maintain alignment among team members and to ensure that all steps were carried out systematically and collaboratively. These efforts collectively ensured that the data was well-organized, reliable and ready for analysis.

From this exercise, it was discovered that only 12 per cent of the treatment group (87 households) had participated in at least one activity from the three components, highlighting a significant delay in reaching treatment households. This low coverage raises concerns about the ability to capture the project's impact and results from the evaluation process within the project's timeline.[18] This low coverage raises concerns about the ability to achieve the intended outcomes within the project's timeline and emphasizes the need for accelerated efforts to engage the

[18] Update 3 July 2025: According to data shared by the IUCN, the number of total beneficiaries has risen to 178 as of March 2025, 157 in the treatment group and 21 in the control group.

remaining households in the treatment group. Table 5 summarizes the distribution of programme component receipt among the 739 households that belong to the treatment group. Of these, 63 households participated in activities from only one component, while 24 households participated in activities belonging to different components. A detailed breakdown of the 87 households that received any activities shows that component 1 was the most accessed (60 households, or 16 per cent of reached households), followed by component 3 (37 households, or 43 per cent of reached households) and component 2 (14 households, or 16 per cent of reached households). Based on the available monitoring data, component 1 brings together a comprehensive set of activities designed to build capacity and resilience. It includes training sessions, the establishment of plots showcasing both agricultural and agroforestry practices alongside demonstration plots, ongoing technical assistance to producers to ensure that lessons learned are effectively applied in the field, the dissemination of climate information so that farmers can anticipate and adapt to weather variability, the introduction of time-saving technologies – both agricultural and non-agricultural – to optimize labour and resource use, structured exchanges of experiences to foster peer learning and finally, the establishment, management and conservation of forests. In contrast, components 2 and 3 are so far much limited in scope. Component 2 focuses on community level activities, including training, plots demonstrating agricultural and agroforestry best practices, technical assistance to producers and the establishment, management and conservation of forests. Component 3 essentially consists of two main activities, namely the dissemination of climate information and training sessions. The monitoring data indicates that treatment exposure is uneven across the intervention area, with priority given to the micro-watersheds of Xayá-Coyolate, Quiejel, La Unión and Tzunamá.

The limited exposure of the treatment sample primarily stems from the IUCN's adoption of a community-based implementation model, which engages beneficiaries through group-based mechanisms rather than direct outreach to sampled treatment households. While this approach facilitates broader community-level engagement and potential scale-up, it diverges from the original sampling frame established for the evaluation; thereby limiting alignment between intervention delivery and the intended impact evaluation design.

Table 5: Treatment exposure by component

	Received one component only	**Received more than one component**	**Component 1**	**Component 2**	**Component 3**
Yes	63	24	60	14	37
No	676	715	27	73	50
Total	739		87		
% Total	12%		69%	16%	43%

Additionally, the monitoring data indicated that five individuals from the comparison group, representing approximately 1 per cent **of the comparison sample, had received project activities.** This cross-contamination poses a potential challenge to the integrity of the evaluation design, as it blurs the distinction between treatment and comparison groups, which is critical to accurately measure the project's impact. Addressing this issue will require careful consideration at the endline to minimize its effect on the validity of the results.

While the treatment sample part of the evaluation is not being reached as expected, the project is reaching a very large number of beneficiaries in the intervention area. According to the most recent data uploaded to the project's monitoring system (March 2025), the project has reached out to more than 100,000 beneficiaries (52 per cent women) with at least one of the three components. According to the information provided by the IUCN team, it is likely that the goal of reaching 132,000 beneficiaries in 2026 will be fulfilled. While components 1 and 2 are relatively advanced in the implementation (about 70 per cent of the target), component 3 is behind schedule in both reaching intended beneficiaries and establishing a fully functional early warning system. Discussions with the IUCN in May and June 2025 indicate that efforts are underway to deliver information to end users via community radio, weather apps, SMS, and by strengthening preparedness at all levels. However, major challenges remain – particularly in communication and dissemination – due to widespread illiteracy and linguistic diversity, including three Mayan languages spoken by Indigenous communities in the project area (K'iche', Mam and Kaqchikel). While initial steps have been taken to provide climate information in locally appropriate languages and formats, substantial improvements are still needed. In any case, it is important to be aware that the activities related to components 1 and 2 began one year before (2021/2022) the activities related to component 3 (2023).[19]

The monitoring data will be revisited again towards the end of the project where the number of beneficiaries receiving training activities and or cash incentives will be identified and based on the disaggregation, the research team will explore the feasibility of a multiple-treatment arm evaluation or simply pooling all project activities under the treatment arm.

5.3.2. Field work and training

The field activities of the midline data collection were conducted between 30 September and 22 November 2024 across five departments in Guatemala, namely Chimaltenango, Quetzaltenango, Quiché, Sololá and Totonicapán.

A total of 16 enumerators and supervisors comprised the field team, along with one field coordinator and one data monitoring specialist. The recruitment process of the local partner gave priority to candidates with relevant experience and suitable local language skills.

The training and pilot session took place over a day and a half on 24 and 27 September 2024. It included an introduction to the implemented project, questionnaire review, key questions from a data quality perspective, practice with the Kobo Collect app, best practices, logistics, supporting files such as maps and local measurement conversion, and a Q&A session to clarify any questions after the pilot.

The C4ED and IUCN were involved during the training session and presented other important topics such as data workflow, data monitoring protocols and research ethics.

In order to facilitate fieldwork planning and tracking, the local partner created a map in the form of a KMZ file to represent GPS coordinates from the baseline in Google Earth.

5.4 Data and Quality Assurance

During the entire data collection period, the evaluation team was given real-time access to the raw survey dataset exported in Microsoft Excel format from the Kobo Collect platform. Therefore, a data monitoring system with high-frequency checks (HFC) was created to ensure high-standard data quality. Thanks to this broad range of checks, there was a thorough review of duplicates in uniquely identifying variables such as IDs, personal identification numbers (DPIs) or phone numbers, missing values, enumerator comments, enumerator performance, outliers among continuous variables, general survey statistics, logic and consistency checks, among others. In addition, tasks including cleaning text-based responses (e.g., the "other" option), adjusting variable names and labels and correcting questionnaire programming errors were simultaneously carried out during and after the field activities. We also provided the project team with all the necessary feedback after each data review twice or three times a week. General comments were shared in a WhatsApp group, whereas household-specific

[19] This refers specifically to reaching beneficiaries. Other activities from Component 3 started in 2020, but were mainly related to the acquisition of infrastructure and community discussions.

comments were pointed out in a shared Excel sheet containing the full sample list. Whenever necessary, the local partner contacted the households again via telephone to double-check specific answers.

The evaluation team also provided the field team with necessary tables of frequencies or descriptive statistics in general whenever requested. Complementarily, different tables containing, for instance, respondents who did not initially provide consent grouped by treatment status as well as by reason for lack of consent were created.

Biweekly meetings took place during that period with the IUCN and the local partner to track progress and resolve issues, especially on the topics of consent and DPIs.

5.4.1. Challenges encountered during data collection

The field team faced typical challenges encountered in a data collection in the context of Guatemala and other developing countries. In terms of obtaining access to communities, a contact person who is familiar with the community leaders or authorities was necessary in many instances. The IUCN helped in this regard thanks to its network in the treatment areas. In other cases, the local partner had to pay an "entrance fee" to gain access to the members of a community.

In terms of reaching out to the respondents, many individuals no longer resided in the community, passed away, refused to be interviewed or were simply unavailable to participate in the survey. Several attempts were often necessary in order to interview the correct household identified in the baseline sample. In some extreme cases, enumerators faced verbal violence and threats which made any attempt to conduct an interview utterly impossible. Security concerns in the targeted regions created an important barrier between data collectors in general and potential interviewees. For similar reasons, it is not uncommon to have the same phone number for different households in the same community.

Among the respondents who completed the forms, many were hesitant to provide personal identifiable information such as DPIs, names and even phone numbers.

Other challenges such as long periods of rain and extreme climate events increased the difficulty of accessing and reaching some communities.

5.5 Software and Code

The Kobo ToolBox data collection tool was adopted to develop the survey and generate the datasets. The tool made it possible to systematize the survey data in real time. This application has a user manual, which specifies the steps for its use according to the type of user. The KoboCollect application was installed on each of the enumerator's devices.

Quality checks during the data collection were done using STATA. It was an essential tool to conduct the high frequency checks, including tasks such as checking for duplicates and outliers, monitoring key variables, preventing data fabrication and tracking progress and enumerator performance. Data cleaning also relies on Stata do-files, which document every step and correction. All do-files, along with raw and processed datasets, questionnaires and codebooks will be stored in the IEU folder, with access restricted to the LORTA team members who have been granted the necessary permissions.

Table 6: List of all software used during the evaluation

Software	Purpose	Project objects derived
Kobo ToolBox	Electronic data collection	Baseline survey instrument; Midline survey instrument

Stata	Statistical analysis	Data monitoring; Data cleaning. Statistical analysis of survey data
Microsoft Excel	Data monitoring	Data monitoring sheets

Source: LORTA team

5.6 Ethics

For the midline data collection, no ethical clearance from a local or international research body, e.g., the Institutional Review Board, was requested. In Guatemala, there is no institution that can provide ethical clearance for the study, and the project team does not have the funding necessary to obtain such clearance from other institutions outside the country. However, the IUCN and LORTA teams revised the midline questionnaire to ensure that it complies with ethical standards and included all the information required to inform participants about the research. Before initiating data collection in each community or village, surveyors sought permission and approval from local community leaders. Consent was granted in all communities except one – La Fe. In this case, the leaders requested that the survey include all 342 households in the village rather than the 24 initially planned. As accommodating this request was not feasible, the community declined to participate in the study. Consequently, La Fe has been excluded from the evaluation.

As shown above, the data was collected using the Kobo Toolbox, which is a data collection tool with robust data protection measures to ensure the security and confidentiality of collected data. For instance, data transmission between devices and the KoBo Toolbox servers is encrypted using hypertext transfer protocol secure (HTTPS), protecting it from interception. Data stored on the KoBo Toolbox servers is protected with strong access controls to prevent unauthorized access, and in addition, the tablets used for data collection were password protected, which adds another layer of security.

Furthermore, the following ethical guidelines were mainstreamed and ensured during the midline data collection:

- Ethical research: The staff of the contracted data collection firm was trained in the core principles for ethical research and evaluation and the consequences of breaking ethical research conduct.
- "Do No Harm" and compliance with local and national legislation: The staff of the contracted firm committed to "do no harm" in their research endeavours and to comply with local legislation and international ethics standards. The staff was required to act in conformity with Guatemala's national laws and to respect local sociocultural norms, traditions and practices when conducting the research. Complete neutrality, impartiality and independence in terms of interests, ideologies, relationships and beliefs were also ensured at all stages of the data collection.
- Informed consent: The contracted firms followed a standard procedure of informed consent for participation in the research. Participants were asked for consent in-person at the beginning of the interview. In addition, respondents were told that their participation was voluntary and that they were able to terminate the interview at any time without any repercussions. It is of utmost importance that respondents do not begin the interview with false expectations about how the research could benefit them or their families. When respondents did not give consent, the interviews did not proceed. As an exception, in the case of midline data collection, some individuals from the treatment group refused to provide consent, arguing that the project team had never reached out to them. To address this, the IUCN is making additional efforts to reach out to these individuals and include them in the implementation pool (and also in the midline survey).

- Context sensitivity: Ethical research also requires sensitivity to the local context. This means that the data collection tools will be adapted to the needs and particularities of the research subjects and the context. Therefore, gender-sensitive questions were checked with local staff to make sure that they were respectful to cultural beliefs. In addition, the data collection involved local female enumerators to avoid any issues with female participants.
- Privacy and safety of respondents: Respondents' safety and privacy were maintained during the data collection. To this end, the IUCN and LORTA team are aware of the need for a private, neutral and secure environment in which the interviews can take place and require that these standards be respected by the contracted local firms. Respondents' safety and their understanding of privacy were maintained during the interviews and all data collected was treated confidentially. For the baseline and midline quantitative survey, data was captured using the Kobo Toolbox, which ensures that data is protected and stored in a safe server. Before analysis and data sharing, data is anonymized. All data produced by the study will only be shared with organisations with whom safe data management procedures have been agreed. The results will be published in a report to the IEU-GCF. No personally identifiable information will be reported or published.

VI. Presentation of Results

This section presents evidence for the outcome and impact variables included in the baseline and midline surveys, as well as some socioeconomic characteristics of the treatment and comparison groups. The comparison among groups is an essential step when implementing the DiD as it assesses the covariate imbalance between treatment and control groups. Significant differences in baseline characteristics may signal that the groups would have followed different trends over time, thereby violating the parallel trends assumption. To address this, it is important to identify and account for these imbalances by including the relevant covariates as controls in the impact analysis. In the DiD with matching approach used here, these covariates will be incorporated into the matching process to improve comparability and strengthen the validity of the causal estimates.

While the table with specific responses to the evaluation questions can be found in Appendix 1, the tables below group the variables across socioeconomic, main and secondary outcomes.[20] For the midline evaluations, balance is not usually required as it was tested at the baseline. However, given the allocation changes among groups and the relatively high attrition, it is relevant to check how different the groups remain. Additionally, given that only a small percentage of the households in the treatment group have been exposed to the intervention, treatment effects will not be estimated, and the results presented in this report will merely be descriptive.

As in the baseline report, in order to conduct the balance checks for the descriptive statistics, we regressed a set of socioeconomic and outcome variables with the treatment variable as an independent variable. The logic behind this approach is to test whether there is a correlation between treatment assignment and the selected dependent variable. Moreover, by conducting a regression-based approach, which simulates a t-test, it is possible to check whether the sample is balanced, meaning that the average values of each variable tested are not significantly different for the treatment and comparison groups. The linear regression was conducted as follows:

$$Y_h = \alpha_0 + \beta_1 T_h + \varepsilon_h \quad (1)$$

In the equation, Y_h represents the variable of interest for each household h – in this case, socioeconomic variables, indicators and final indices T_h. denotes the treatment variable that takes the value 0 if a household is in the comparison group and 1 if a household is in the treatment group. ε_h is the error term. We cluster standard errors at the micro-watershed level. We test the hypothesis $\beta_1 = 0$.

After assessing the balance of socioeconomic characteristics, outcome variables and other key factors, we will present the propensity score estimation results and evaluate the extent of the common support at this (midline) stage. While it is likely that the common support will change due to an additional expected attrition, it is important to check at this point whether the evaluation design is still valid. As described in section, the evaluation uses a DiD approach with matching design to estimate the Average Treatment effects on the Treated (ATT). The matching approach provides, within the DiD set-up, that the most similar units between the treatment and comparison groups are compared to measure the effect of the programme. For a robust estimation, matching relies on two key assumptions: conditional independence (CI) and common support (CS). Common support refers to the extent of overlap in key matching variables between the treatment and comparison groups. The larger the number of households that are matched, the more robust the estimates will be. To assess the common support, the first step is to estimate the propensity scores and therefore, the CI assumption becomes key as it relates to the ability to observe and capture all variables that predict the probability of being a beneficiary of the programme and that are also correlated to the outcomes of interest (i.e. before project implementation).

To estimate propensity scores, a logistic regression will be used modelling the treatment assignment as a function of relevant covariates (see Equation 2). Once estimated and the common support has

[20] Sampling weights were not applied in the analysis as it is not possible to know the universe of farmers that would be eligible to participate in the programme. Given the random selection of communities within the micro-watersheds and of eligible participants, the results can be taken as representative of the included micro-watersheds.

been assessed, the propensity scores can be used for matching. Before proceeding to the estimation, we will also check the balance across groups after applying propensity score adjustments to ensure comparability and mitigate confounding effects.

$$P(X_h) = \frac{e^{\beta_0+\beta_1 X_{h1}+\beta_2 X_{h2}+\cdots+\beta_k X_{hk}}}{1+e^{\beta_0+\beta_1 X_{h1}+\beta_2 X_{h2}+\cdots+\beta_k X_{hk}}} \quad (2)$$

Where $P(X_h)$ is is the probability that household h receives the treatment ($T_h = 1$), given their observed covariates X_h. In addition, , β_0 is the intercept and $\beta_1, \beta_2, \ldots, \beta_k$ are the estimated coefficients for each covariate and $X_{h1}, X_{h2}, \ldots, X_{hk}$represent the observed baseline characteristics that explain treatment allocation. The logistic function ensures that the estimated propensity scores fall within the range [0,1].

6.6.1. Socioeconomic characteristics

The socioeconomic characteristics of the sample from the Highlands of Guatemala offer valuable insights into the demographic and economic conditions of this region. The Highlands are known for their rich cultural heritage and diverse Indigenous populations and create unique challenges and opportunities in terms of access to resources, education and employment. Understanding these characteristics is essential for contextualizing the social and economic dynamics that influence the lives of individuals and communities in this area, as well as informing policies and interventions aimed at addressing local needs and fostering sustainable development. As mentioned above in Section V, testing balance in these characteristics help us determine how comparable the treatment and comparison groups selected for the impact evaluation are, ensuring that any observed differences in outcomes can be attributed to the intervention rather than underlying disparities between the two groups.

Regarding their socioeconomic characteristics, the results demonstrate only minor differences between the treatment and comparison groups, which is crucial for ensuring comparability in subsequent analysis. However, when considering the results from the baseline, they are slightly different in terms of household composition, and particularly in the number of children. The differences in mobile phone ownership observed at the baseline persist. It is worth noting that, in order to make the report more informative for the programme implementers, the socioeconomic characteristics included in the midline analysis are based on information from household heads rather than from the survey respondents, as in the baseline report.

In terms of gender distribution, about 21 per cent of household heads are women. This figure is slightly higher than national statistics (INE, 2021), which indicate that 16 per cent of agricultural producers in the Highlands of Guatemala are female. Most surveyed households are biparental (75 per cent), which aligns to what was found at the baseline (82 per cent). The average age of the household head is around 50 years old, with the comparison group having older household heads (53 years old) in relation to the treatment group (49 years old). Regarding education, approximately 42 per cent of household heads (either female, male or both) across treatment and comparison groups did not receive any education. Nearly 50 per cent started but did not complete primary education, while 27 per cent did complete it.[21] Overall, both groups have similar education profiles. These characteristics align closely with the regional profile of farmers reported in the (last) census of 2018 from the National Institute of Statistics – INE, where 24 per cent of surveyed individuals from the rural central Highlands reported not attending school, 44 per cent completing primary school and 27 per cent reported attending high school. Overall, the low level of literacy is a widespread problem in the region.

Household size and composition are also comparable with an average of around five members in both comparison and treatment groups. However, when examining the total number of children under 18

[21] Education levels do not add to 100 per cent as we take the highest education level reported for the household head. This applies to monoparental but also to biparental households.

years old in a household, respondents report an average of 1.6 children per household in the comparison group and of 2 in the treatment group. This difference is significant at the 1 per cent level. It may suggest that households in the treatment group are more vulnerable than those in the comparison group, as they have a higher number of dependent members. Yet, there are no apparent differences on household income or in access to services such as the internet or electricity. In terms of assets, there are statistically significant differences on home ownership with a larger percentage of households in the treatment group (95 per cent) that reported owning a house versus the comparison group (88 per cent). This is similar when looking at mobile phone ownership (85 per cent versus 76 per cent).

As shown below, in the midline data collection about half of participants reported having a monthly income between 1,001 to 3,000 Guatemalan quetzal(GTQ) (USD 120 - 360)[22], and 25 per cent from the total sample reported having an income below GTQ 1,000 (USD 120 or below). About 20 per cent of the remaining sample reported earning a monthly income between GTQ 3,001-5,000 (USD 361-600), and only a small share (3 per cent) earns more than USD 600 in a month. No statistically significant differences among treatment and comparison groups were found in any of the categories at the midline.

Table 7 presents socioeconomic characteristics and balance checks for socioeconomic variables using a pairwise t-test.

Table 7: Socioeconomic Characteristics: Balance of Comparison vs. Treatment groups

Variable	(1)	(2)	(3)	(2)-(3)
	Total	**Comparison**	**Treatment**	**Pairwise t-test**
	Mean/(SE)	**Mean/(SE)**	**Mean/(SE)**	**Mean difference**
Female-headed household	0.206	0.230	0.189	0.041
	(0.014)	(0.020)	(0.016)	
Household jointly headed by a male and a female	0.751	0.720	0.773	-0.053*
	(0.017)	(0.020)	(0.020)	
Age of household head	50.436	52.714	48.843	3.871**
	(0.951)	(1.084)	(1.200)	
Household head did not complete any education level	0.419	0.449	0.398	0.051
	(0.036)	(0.057)	(0.044)	
Household head did not complete primary education	0.496	0.484	0.505	-0.021
	(0.015)	(0.021)	(0.020)	
Household completed primary education	0.272	0.248	0.290	-0.042
	(0.024)	(0.036)	(0.029)	
Household head completed lower secondary education	0.109	0.081	0.129	-0.047*
	(0.015)	(0.018)	(0.018)	
	0.081	0.091	0.074	0.016

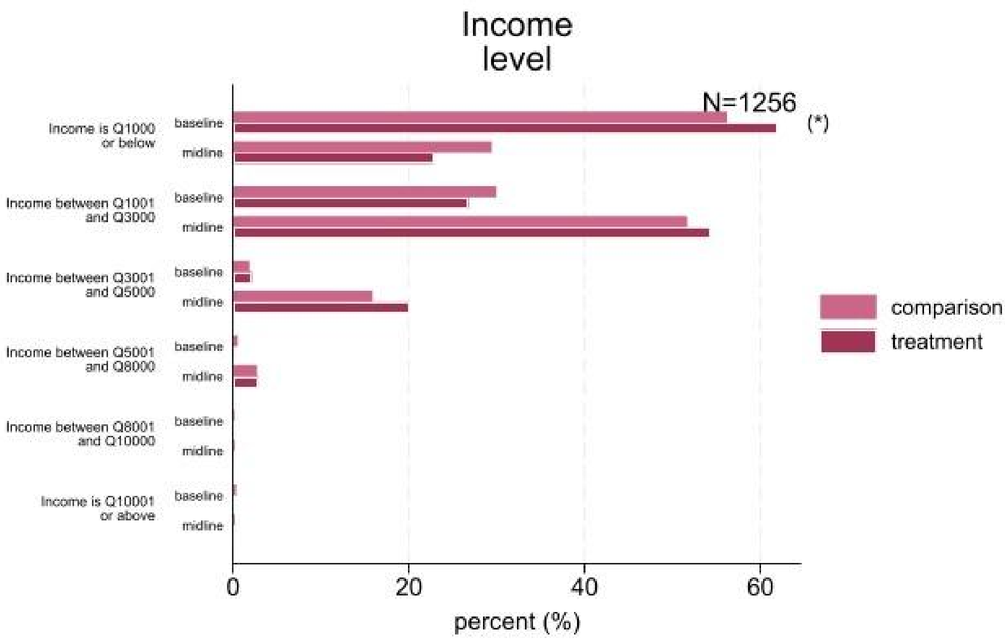
[22] Exchange rate as of 21 February 21 2025.

Household head completed higher secondary education	(0.012)	(0.022)	(0.014)	
Household head completed university	0.012 (0.003)	0.014 (0.006)	0.011 (0.004)	0.003
Household head completed adult education	0.004 (0.003)	0.000 (0.000)	0.007 (0.004)	-0.007
Number of children in the household	1.866 (0.104)	1.594 (0.097)	2.057 (0.133)	-0.463***
Number of adults in the household	2.959 (0.088)	2.853 (0.105)	3.034 (0.126)	-0.181
Number of elderly in the household	0.380 (0.030)	0.420 (0.044)	0.352 (0.039)	0.068
Income is 1000 Guatemalan quetzal or below	0.255 (0.024)	0.294 (0.033)	0.227 (0.030)	0.067
Income is between 1001 and 3000 Guatemalan quetzal	0.532 (0.016)	0.516 (0.021)	0.543 (0.023)	-0.026
HH owns their house	0.921 (0.014)	0.878 (0.020)	0.951 (0.010)	-0.073***
HH has internet connection (either mobile internet or at home)	0.148 (0.017)	0.137 (0.029)	0.156 (0.019)	-0.018
HH has a mobile phone	0.809 (0.016)	0.756 (0.023)	0.846 (0.015)	-0.089***
N	1256	517	739	
Cluster	34	10	24	
HH has electricity	0.972 (0.004)	0.967 (0.006)	0.976 (0.005)	-0.009
N	1254	516	738	
Cluster	34	10	24	

Note: The "Total" column displays information for the entire sample. The value displayed in the last column is the mean difference based on a linear regression with standard errors clustered at the micro-watershed level. Standard errors are shown in brackets. Statistical significance is indicated by ***, ** and * at the 1%, 5% and 10% critical levels, respectively.

With respect to the baseline results, it is worth mentioning that both treatment and comparison groups have improved substantially. While most of the sample (roughly 60 per cent) reported a monthly income below 1,000 Guatemalan quetzal at the baseline, most participants are placed in the category of 1001-3000 Guatemalan quetzal during the midline (see Figure 6). Similarly, the percentage of participants reporting higher monthly salaries (above 3000 Guatemalan quetzal) increased between the baseline and midline for both groups, although the change is more prominent for the treatment group.

Figure 6: Monthly household income categories by group and wave

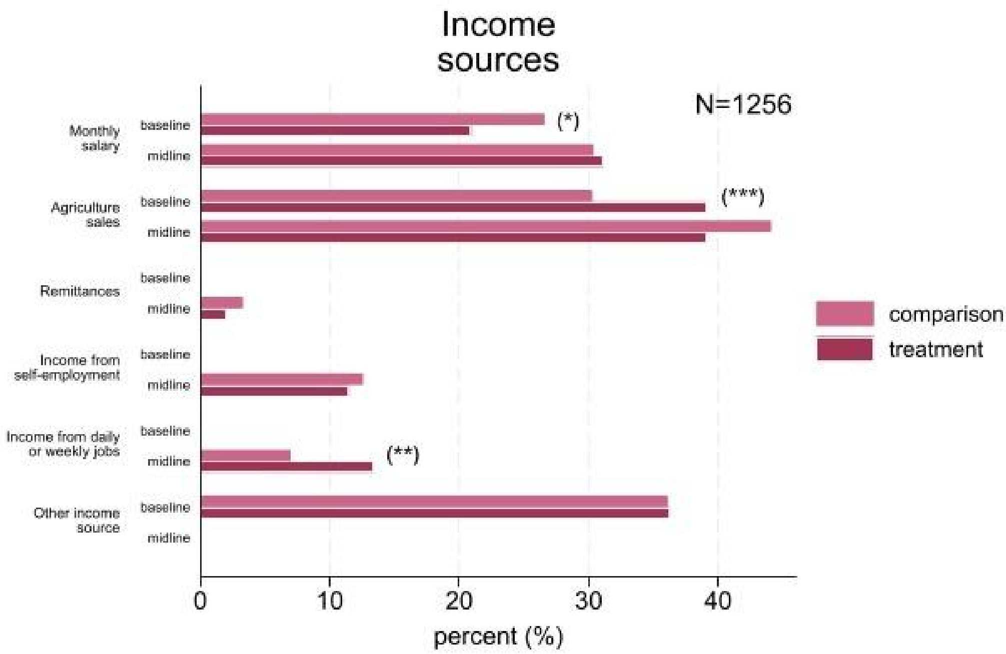


Source: Own elaboration

When exploring potential reasons for the rise in income, clear conclusions cannot be drawn. As shown in Figure 7, while most of the income of household heads in both treatment and comparison groups at the midline comes from agricultural sales, there are structural changes on income composition from both groups compared to the baseline. For instance, a larger share of household heads from the treatment group reported monthly salaries as their main income source compared to the baseline (from 21 per cent versus 31 per cent), while the share of household heads reporting agricultural sales as their main income source remains constant at 40 per cent. In addition, significantly more treated households receive income from daily or weekly jobs when compared to the comparison group. This finding suggests that either the treatment group may be compensating for losses in agriculture due to climate change by engaging in non-agricultural work and/or, a portion of the treated sample may have ceased cultivating and commercializing agricultural products altogether.

In contrast, the comparison group appears to be experiencing the opposite trend. A larger share of household heads reported agricultural sales as their main source of income compared to the baseline (from 30 per cent to 44 per cent), while those reporting a monthly salary as their main income source remain similar in both waves between 27 per cent-30 per cent.

Figure 7: Main income sources from household head by group and wave



Source: Own elaboration

6.6.2. Resilient and Diversified Livelihood Index

This index measures resilience that is essentially economic: the resilience of livelihoods for individuals who are exposed to climate shocks. While this index gives an approximation of how vulnerable and resilient a household is by proxying how well a household can cope with a climate-related shock, it does not predict how fast they can recover from it. The composition of this index was based on previous work by members of the IUCN team and was thoroughly discussed with the LORTA team.

The index was estimated using the Anderson Index methodology (see Anderson, 2008), which is based on a generalized least squares estimation and can be explained as the weighted mean of a set of standardized variables/indicators. This statistical method can be used with all variable types: binary, ordinal, categorical or continuous. It first standardizes all variables (which makes it easier to interpret treatment effects) and then squeezes them, by assigning different weights to variables, into a single value. Under this methodology, highly correlated indicators receive less weight than uncorrelated indicators. Moreover, it considers all data but ascribes lower weight to indicators with missing values. This method also replaces missing information with the mean of the normalized indicator (zero).

Table 8 presents the descriptive statistics of the Resilient and Diversified Livelihood Index, calculated with the Anderson methodology, as well as of components that underlie the index. As shown, no statistically significant differences are present in treatment and comparison groups. The normalization is performed with the overall sample (therefore the mean is equal to zero), as well as taking the comparison group at midline as reference (therefore the mean for the comparison group is equal to zero). The reference group for this midline report is the comparison group at midline and not at baseline, as the exposure to treatment is at this point very small (12 per cent) and therefore observed changes are difficult to be attributed to treatment.[23]

[23] Based on data from June 2024.

Regarding multidimensional poverty, households obtained a 41-point score on average with no statistically significant differences between treatment and comparison groups. This applies to the weighted score as well as for each of its components. This score is slightly greater than in the baseline, where households obtained an average of 40 points. Following the report from URL & IARNA (2020), households in the Highlands of Guatemala can be on average classified as poor.[24] The difference between the midline and baseline can be mainly attributed to the score for the income category, which is higher in the midline (10.9 points in the midline versus 8.8 in the baseline). This is also in line with the results described above.

With respect to the water accessibility variable, 47 per cent of households reported their water access for consumption as sufficient and 13 per cent as insufficient, which is an increase compared to the baseline results where 37 per cent of households reported their access as sufficient and 20 per cent as insufficient. The principal source of water in the surveyed households comes from a home connection (68 per cent of the households versus 75 per cent at the baseline – not shown), followed by those with a family-owned or community-owned well (17 per cent versus 16 per cent at the baseline – not shown). The decline in home water connections may be attributed to inadequate service quality. A comparison of the baseline and midline data suggests a shift toward alternative water sources – primarily public standpipes and family- or community-owned wells – to ensure water accessibility. Three per cent of households collect water from surface sources (river, lake or spring), and 0.3 per cent collects rainwater (not shown). Water quality is also an important aspect to consider and is the only variable from this index that is not balanced among treatment and comparison groups. On average, 19 per cent of households reported that water quality improved in the last 12 months, yet the number of households reporting improvements is statistically significantly higher in the treatment group compared to the comparison group (23 per cent versus 15 per cent - not shown).

In addition to livelihoods, other dimensions which this index considers are resource and agricultural diversification. The first is captured by a variable measuring the number of forest products households collect as usually those are not reported under agricultural production or income and are likely being utilized for self-consumption. The second is captured by the number of different crops produced by households and is measured using the Simpson-Herfindahl Index. As shown below, households reported collecting about 13 per cent (or between 1-2 products) from a total of eight forest products given as options in the survey (e.g., wild fruits, medicinal plants, leaves, firewood, wood, mushrooms, charcoal, etc.). This value is similar to the one found in the baseline, and no statistically significant differences are found. The most common products collected are wood (71 per cent in the midline versus 65 per cent in the baseline – not shown) and mushrooms (20 per cent in the midline versus 13 per cent in the baseline – not shown). The majority of households, about 74 per cent, reported collecting at least one type of forest product. All households collecting forest products use them for family consumption, and 94 per cent affirmed that there are less forest products compared to three years ago. It is also observed that there is a low diversification of agricultural products, as the Simpson-Herfindahl Index has an average value of 0.28 (out of a maximum score of 1). The most commonly harvested products are maize and beans (not shown). In addition, the agricultural diversification decreased compared to the baseline where the Simpson-Herfindahl Index was 0.39 and classified as low-medium diversification. This shows that on average, households are reducing the number of crops they produce. Several (untested) reasons can be put forward: i) changes in rainfall damaging crops; ii) desire to focus or specialize in one or two crops; and iii) substitution of agricultural work to non-agricultural work. These reasons align with the income changes discussed above.

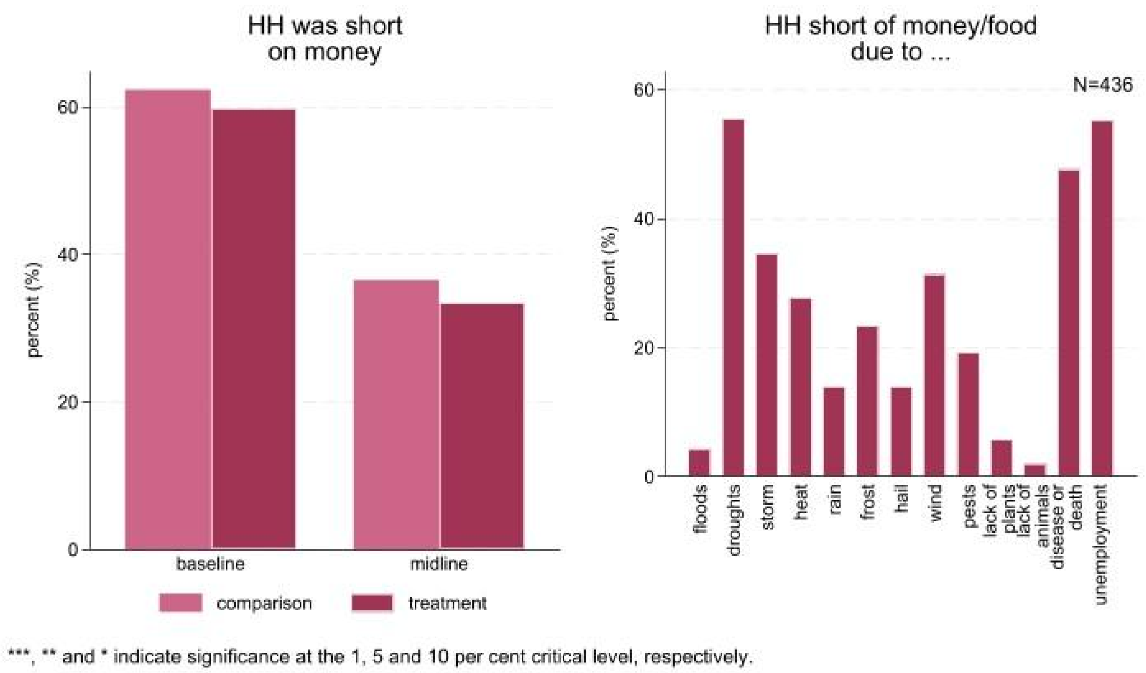
The last variable composing the index reflects the percentage of households classified as not vulnerable to climate change. This variable is calculated as the percentage of households reporting shortages of money or food due to reasons different to climate shocks (i.e. sickness, unemployment). Before going into that specific indicator, it is relevant to first understand how many households reported money shortages. Accordingly, the left-hand side of Figure 8 compares the percentage of

[24] Based on the report, households with 30-67 points can be classified as poor.

households that reported money shortages at the baseline and midline for both the comparison and treatment groups. At the baseline, the percentage of households short on money was above or very close to 60 per cent for both groups, with no statistically significant difference between them. By the midline, the percentage of households reporting a shortage of money decreased in both groups, with the treatment group showing a slightly lower percentage than the comparison group (33 per cent versus 37 per cent), but the difference is also not statistically significant. The right-hand side of Figure 8 shows the different reasons that explain financial shortages. As shown, unemployment and death of a family member are commonly reported factors, as well as climate-related causes such as droughts, storms, extreme heat, strong winds, etc.

The "Not vulnerable to climate change" variable shown in Table 8, thus corresponds to the proportion of households reporting money or food shortages due to factors not related to climate, which is the majority of sampled households (on average 75 per cent). That means that 25 per cent of households reported that during the last 12 months they lacked food or money in their household due to climate shocks. This shows a significant increase in vulnerability compared to the baseline where only 17 per cent reported a lack of money or food due to climate shocks.

Figure 8: HHs reporting money shortages and reasons by group and wave



Source: Own elaboration

Given the slight differences between the treatment and comparison groups, as shown in the last column of the table, we conclude that, on average, the groups are comparable with respect to the characteristics measured by the first index.

Table 8: Resilient and Diversified Livelihoods Index: Balance of Comparison vs. Treatment groups

Variable	(1)		(2)		(3)		(2)-(3)
	Total		Comparison		Treatment		Pairwise t-test
	N/Clusters	Mean/ (SE)	N/Clusters	Mean/ (SE)	N/Clusters	Mean/ (SE)	Mean difference

Index 1 - Anderson (all variables, normalization based on full sample)	1256	0.000	517	-0.087	739	0.061	-0.147
	34	(0.057)	10	(0.075)	24	(0.074)	
Index 1 - Anderson (all variables, normalization based on comparison group)	1256	0.082	517	0.000	739	0.139	-0.139
	34	(0.057)	10	(0.073)	24	(0.075)	
Multi-dimensional Poverty Index: Overall	871	41.507	315	41.283	556	41.634	-0.352
	34	(0.774)	10	(1.365)	24	(0.949)	
Multi-dimensional Poverty Index: Education	1256	9.136	517	8.609	739	9.504	-0.894
	34	(0.456)	10	(0.714)	24	(0.526)	
Multi-dimensional Poverty Index: Life quality	1236	14.622	504	14.782	732	14.512	0.269
	34	(0.345)	10	(0.368)	24	(0.528)	
Multi-dimensional Poverty Index: Income	1256	10.859	517	11.303	739	10.548	0.755
	34	(0.333)	10	(0.562)	24	(0.430)	
Multi-dimensional Poverty Index: Food security[a]	885	7.436	324	7.272	561	7.531	-0.259
	34	(0.130)	10	(0.136)	24	(0.187)	
HH has sufficient drinking water	1256	0.471	517	0.427	739	0.502	-0.075
	34	(0.031)	10	(0.044)	24	(0.040)	
HH has insufficient drinking water	1256	0.131	517	0.128	739	0.133	-0.005
	34	(0.012)	10	(0.015)	24	(0.017)	
HH reports improved water quality	1256	0.197	517	0.151	739	0.23	-0.079**
	34	(0.018)	10	(0.024)	24	(0.018)	
No. of forest products household collects	1256	0.132	517	0.135	739	0.130	0.006
	34	(0.007)	10	(0.009)	24	(0.011)	
Not vulnerable to climate change (yes/no)	1256	0.755	517	0.752	739	0.756	-0.004
	34	(0.024)	10	(0.042)	24	(0.031)	
Simpson-herfindahl Index	1139	0.28	471	0.24	668	0.308	-0.069
	34	(0.030)	10	(0.044)	24	(0.038)	

Note: The "Total" column displays information for the entire sample. The value displayed in the last column is the mean difference based on a linear regression with standard errors clustered at the micro-watershed level. Standard errors are shown in brackets. Statistical significance is indicated by ***, ** and * at the 1%, 5% and 10% critical levels, respectively.

[a] Reduction of sample size due to households not having members under 18 years old.

6.6.3. Responsivness Index

The Responsiveness Index captures household and community capacity to perceive and respond to the effects of climate change. The index was tested in other projects implemented in the Guatemalan Highlands by IARNA (see URL & IARNA, 2020) and adapted to this evaluation by the IUCN

Guatemala. It includes agricultural and natural resource management practices at the plot level, as well as community response capacity. This index is composed of four indicators and measures how responsive a household is towards climate risks and future shocks. This index also takes into account the existence and use of EWS at the community level. Hence, the indicator captures variation not only among households but also among communities.

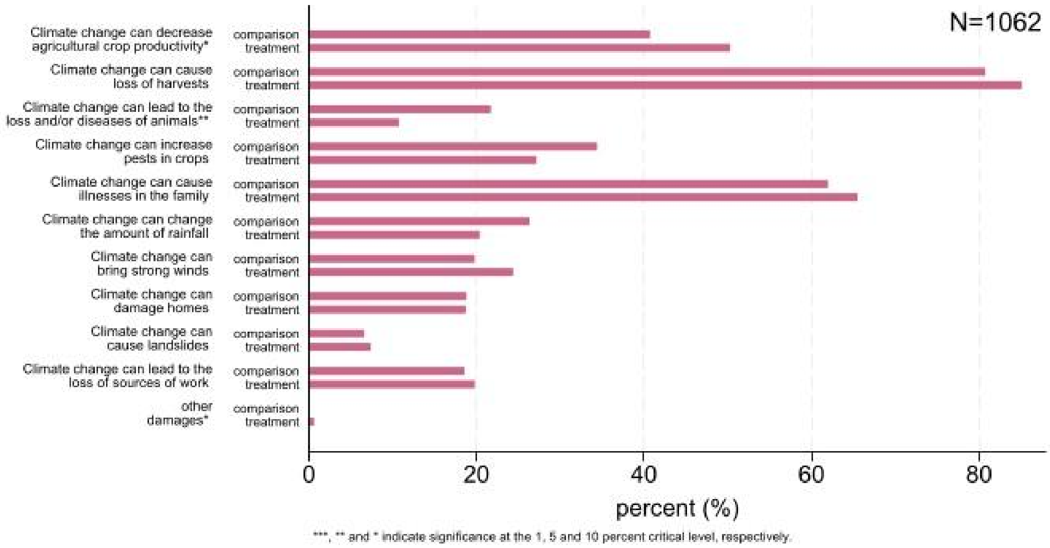
Table 9 shows the descriptive statistics and balance checks for the Responsiveness Index. As shown in the first two rows, there are no statistically significant differences on the index between treatment and comparison groups. As explained above, the reference group used is the comparison at the midline instead of the baseline as exposure to treatment is very low and therefore, difficult to attribute observed changes to the project. Overall, none of the indicators composing the index show statistically significant differences between treatment and comparison groups. Taking the results from the first index, there is already some balance between the groups before applying the matching method.

An analysis of each indicator individually reveals that, on average, households reported awareness of 28 per cent equivalent to 2-3 items – from a list of 10 describing the negative impacts of climate change. This number increased compared to the baseline where households reported knowing only 1-2 items from the same list (18 per cent). Consistent with this finding, 75 per cent of households responded “yes” in the baseline survey when asked whether they believe climate change can negatively affect household members or assets, with no statistically significant differences between treatment and comparison groups. By the midline, this proportion increased to 85 per cent, and statistically significant differences were observed, with the treatment group more likely to respond “yes” (88 per cent versus 79 per cent - not shown). While these differences could be attributed to the project’s awareness activities over the past two years, it’s important to be cautious, as exposure to treatment was very low at the point of data collection and therefore, the observed changes could also be due to other projects or initiatives in the area.

The majority of households identified loss of harvests (83 per cent of those who answered “yes”), illnesses in the family (64 per cent of those who answered “yes”) and decrease in crop productivity (47 per cent of those who answered “yes”) as the most prevalent negative effects of climate change (see Figure 9). It is crucial for farmers to be aware of the negative consequences of climate change because their livelihoods are directly tied to environmental conditions. Changes in temperature, rainfall patterns and the frequency of extreme weather events can significantly affect crop yields, soil health and the overall success of farming. By being aware, farmers can make informed decisions on adopting agricultural practices such as crop selection, irrigation practices and pest management to adapt to shifting conditions. Awareness also helps farmers plan for future challenges, such as prolonged droughts or floods, and invest in sustainable farming practices that improve resilience to climate-related risks. Furthermore, being informed about climate change allows farmers to invest in infrastructure to protect their crops and their assets. Yet, while awareness of the effects of climate change is crucial, it is not sufficient as farmers must also have the knowledge and resources to implement effective mitigation strategies to reduce its impact and enhance resilience.

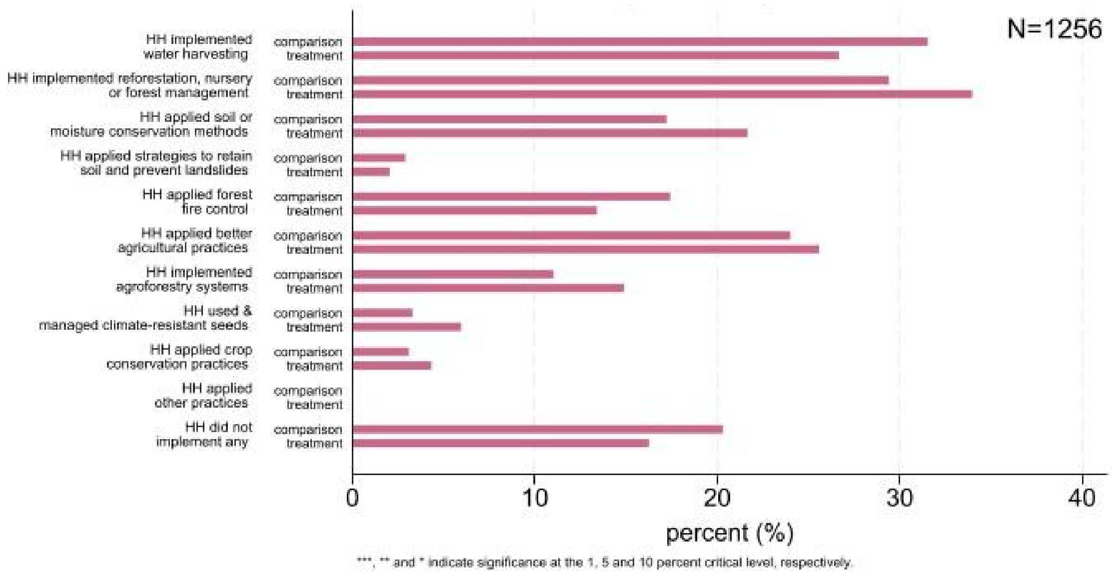
In this regard, 94 per cent of households reported knowing at least 1 of the 13 measures/strategies against climate change, increasing significantly from the 61 per cent observed at the baseline. Yet, households know on average two of the mentioned practices or 15 per cent of them (which is significantly higher from the 9 per cent or on average one practice found at the baseline), and no statistically significant differences are found between treatment and comparison groups. While awareness and knowledge have increased since the baseline and are now at relatively high levels, the next step on the behavioural change process is the adoption of practices to mitigate climate change damage. As to this, it is found that 82 per cent of households reported adopting at least one strategy against climate change on their plot (see more on climate change mitigation in Table 11). Figure 10presents the results for each practice by group. The most common practices adopted by households on their plots are reforestation (32 per cent on average), water harvesting (28 per cent on average) and better agricultural practices (25 per cent on average). No statistically significant differences between treatment and comparison groups are found.

Figure 9: Consequences from climate shocks reported by group (midline only)



Source: Own elaboration

Figure 10: Practices to mitigate climate change damage in plot by group (midline only)



Source: Own elaboration

Lastly, households reported limited awareness and use of community-level EWS (on average 8 per cent and 10 per cent, respectively) with no statistically significant differences between treatment and comparison groups. Generally speaking, from those who reported the existence of an EWS, either male (29 per cent) or both male and female (30 per cent) joined activities related to the EWS at the community level. Similarly, the majority of households (86 per cent) reported that the community lacks an emergency plan for floods, landslides or droughts. Overall, while households have gained more knowledge about climate change effects, mitigation measures and the risks associated with climate shocks compared to the baseline, behavioural change in the use of early warning systems (EWS) is lacking. EWS is either not functioning effectively, is not being utilized by communities or households do not associate the receipt of climate information with actionable EWS responses. Although climate information is widely disseminated across both treatment and comparison groups – primarily via radio, television and social media – this is not translating into improved awareness or use of EWS. At the same time, communities appear unprepared to respond when climate shocks occur. EWS plays a crucial role in managing and mitigating the impacts of natural disasters and climate-related events. When communities are aware of potential risks and understand how to respond, they become more resilient and proactive in disaster situations. Beyond issuing alerts, EWS helps cultivate a culture of preparedness, ensuring that people are trained and ready to act swiftly when needed.

Table 9: Responsiveness Index: Balance of Comparison vs. Treatment groups

Variable	(1)		(2)		(3)		(2)-(3)
	Total		Comparison		Treatment		Pairwise t-test
	N/Clusters	Mean/ (SE)	N/Clusters	Mean/ (SE)	N/Clusters	Mean/ (SE)	Mean difference
Index 2 - Anderson (normalization based on comparison group)	1256	-0.000	517	-0.065	739	0.045	-0.111
	34	(0.079)	10	(0.121)	24	(0.108)	
Perceived risk on climate change (average # of answers)	1256	0.279	517	0.261	739	0.291	-0.029
	34	(0.011)	10	(0.022)	24	(0.010)	
Awareness of measures against climate change (average # of answers)	1248	0.152	515	0.146	733	0.156	-0.010
	34	(0.005)	10	(0.011)	24	(0.003)	
Existence of EWS (average by community)	1256	0.081	517	0.081	739	0.080	0.001
	34	(0.007)	10	(0.008)	24	(0.012)	
Using information from EWS (average by community)	1230	0.106	499	0.108	731	0.104	0.004
	34	(0.009)	10	(0.010)	24	(0.013)	

Note: The "Total" column displays information for the entire sample. The value displayed in the last column is the mean difference based on a linear regression with standard errors clustered at the micro-watershed level. Standard errors are shown in brackets. Statistical significance is indicated by ***, ** and * at the 1%, 5% and 10% critical levels, respectively.

6.6.4. RIMA

Table 10: RIMA Index: Balance of Comparison vs. Treatment groups

Variable	(1) Total Mean/(SE)	(2) Comparison Mean/(SE)	(3) Treatment Mean/(SE)	(2)-(3) Mean difference
Take diversification action	0.059 (0.007)	0.049 (0.006)	0.068 (0.007)	-0.019
Diversification problems	0.059 (0.007)	0.081 (0.008)	0.038 (0.005)	0.043

Education index (normalized)	0.400 (0.009)	0.449 (0.009)	0.351 (0.008)	0.098
Will be affected by droughts	0.414 (0.012)	0.178 (0.011)	0.650 (0.013)	-0.472
Risk perception	0.801 (0.011)	0.757 (0.012)	0.845 (0.010)	-0.088
Asset index	0.006 (0.027)	-0.030 (0.026)	0.042 (0.027)	-0.072
Experienced climate change	0.808 (0.011)	0.770 (0.012)	0.846 (0.010)	-0.076
Social safety nets	0.089 (0.008)	0.119 (0.009)	0.060 (0.007)	0.059
Not affected by climate	0.797 (0.011)	0.840 (0.010)	0.755 (0.012)	0.085
Improved latrine	0.335 (0.013)	0.283 (0.013)	0.387 (0.014)	-0.104
Land area (hectares)	0.317 (0.053)	0.406 (0.093)	0.227 (0.013)	0.179
Father diversified	0.062 (0.007)	0.059 (0.007)	0.065 (0.007)	-0.006
Dietary diversity score	6.807 (0.059)	6.678 (0.065)	6.936 (0.053)	-0.258
Income level	1.680 (0.019)	1.368 (0.017)	1.992 (0.021)	-0.624
Absorptive capacity	0.005 (0.044)	0.105 (0.042)	-0.094 (0.046)	0.199
Adaptive capacity	0.026 (0.026)	-0.228 (0.027)	0.279 (0.026)	-0.507
Transformative capacity	-0.189 (0.056)	-0.143 (0.058)	-0.234 (0.053)	0.091
RCI (all components)	0.034 (0.022)	-0.112 (0.020)	0.180 (0.023)	-0.292

As shown, the overall sample demonstrates relatively low engagement in diversification actions, with only 6 per cent of households (on average) having taken diversification measures in response to shocks, and a similar proportion (6 per cent) encountering problems when attempting to diversify income or production activities. No statistically significant differences are observed between treatment and comparison groups for these behavioral indicators.

Regarding risk perception and climate awareness, notable differences emerge between the groups. While 41 per cent of households overall believe they will be affected by droughts, this perception varies significantly by group, with 65 per cent of treatment households expressing this concern compared to only 18 per cent of comparison households. Similarly, treatment households demonstrate higher overall risk perception (0.85 versus 0.76) and are more likely to report having experienced climate change events (85 per cent versus 77 per cent). Despite these differences in risk awareness, both groups show similar levels of resilience when measured by the proportion not affected by climate events (76 per cent treatment versus 84 per cent comparison).

Socioeconomic characteristics reveal some disparities between groups. The education index shows comparison households having slightly higher normalized education levels (0.45 versus 0.35), while treatment households report higher income levels (1.99 versus 1.37) and better access to improved sanitation facilities (39 per cent versus 28 per cent). Asset ownership and land area cultivated show minimal differences between groups. Dietary diversity, an important indicator of food security, appears slightly higher among treatment households (6.94 versus 6.68), though the practical significance of this difference requires further assessment.

The RIMA framework uses three key capacity measures that capture different dimensions of resilience. Absorptive capacity, which reflects the ability to cope with and absorb shocks through preparedness and buffers, shows comparison households performing slightly better (0.11 versus -0.09). In contrast, adaptive capacity – measuring flexibility to adjust and modify livelihood strategies – is notably higher among treatment households (0.28 versus -0.23). Transformative capacity, representing long-term institutional and social factors that enable fundamental changes, shows minimal differences between groups. When combined into the overall Resilience Capacity Index (RCI), treatment households demonstrate higher overall resilience (0.18 versus -0.11), suggesting that despite facing greater perceived climate risks, they may possess stronger adaptive mechanisms to respond to food insecurity and other shocks

6.6.5. Other Indicators

Following the discussion on climate change awareness, knowledge and adoption, Table 11 presents a balance between treatment and comparison groups on different climate-related indicators, especially on the mitigation measures adopted by households. As shown, 92 per cent of households (on average) reported experiencing a climate shock in the 12 months before the survey. This value is statistically significant compared to the 77 per cent (on average) reported at the baseline. The increase is similar between the treatment and comparison groups and no statistically significant differences are found. While climate shocks seem to be occurring throughout the year, most households reported weather shocks in May (planting season) to July, and 34 per cent reported climate shocks twice in the last 12 months.

When respondents were asked how well-informed their household members are about environmental and climate change effects, an average of 28 per cent answered "well" or "very well" – a notable increase from the baseline average of 11 per cent. This enhanced awareness, along with greater knowledge and firsthand experiences of climate-related events, coincided with a broader adoption of strategies to mitigate climate change impacts. It is found that the majority of households reported adopting strategies to mitigate climate change damage in general (e.g., reforestation, using a variety of seedlings, taking care of water sources such as springs, rivers, lakes, wells, conserve soils, etc.) and also on their plot (see Figure 10). When exploring particular and relevant conservation practices, 63 per cent of households reported applying soil conservation techniques such as stubble management (e.g. for cover crops), use of live barriers or implementing contour planting. Another finding concerns the use of improved seeds, which offer greater resilience to climate-related events. Our understanding is that while the IUCN encourages and expects their use, no specific training encouraging the use of improved seeds has been incorporated into the intervention activities. This explains why only nearly 6 per cent of households (on average) reported using improved seedlings. To provide some background on this, seedlings come from three sources: native, creole or improved. Native seeds originate from a specific region and have naturally adapted to their environment without human intervention. Creole seeds come from native varieties but have been selectively preserved and improved by farmers over generations, maintaining genetic diversity while adapting to local conditions. Improved seeds are developed through scientific breeding programmes to enhance yield, pest resistance, drought tolerance or nutritional value. From the information reported by households, creole seedlings are the most used, followed by native and improved ones. Overall, no major changes in the use of seedlings are found with respect to the baseline.

Regarding landholding characteristics, the average size of plots is nearly identical in the treatment and comparison groups at around 0.2 hectares per household, which is slightly smaller compared to the baseline where the average size was 0.39 hectares (see Table 12). The reduction in land size aligns with the discussion on changes in income patterns, as 97 households (59 in the treatment and 38 in the comparison group) did not report plot size information –all of whom indicated that their land was either left fallow or sold. This also explains the decrease in the sample size for this variable, from 1256 total observations to 1159. Regarding crop composition, the majority of the households (98 per cent on average) harvest annual crops such as such as maize, beans or rice and a very few proportion of households (7 per cent on average) reported harvesting perennial crops such as fruit trees (where a statistically significant difference between treatment and comparison is shown). The production harvest remains very similar to the baseline, where a similar distribution between annual and perennial crops was found (95 per cent and 8 per cent, respectively).

Agroforestry systems are widely implemented in local plots, with the milpa being the most common (see Figure 11). This traditional system involves intercropping maize, beans and güicoy or squash, creating a symbiotic relationship that enhances soil fertility and crop productivity. In the Highlands of Guatemala, the milpa is a cornerstone of traditional agroforestry and sustainable agriculture, particularly among Indigenous and rural communities. By mimicking natural ecosystems, it promotes biodiversity, strengthens resilience and supports both food security and environmental conservation. Its diverse cropping approach makes it a valuable strategy for climate adaptation and long-term sustainability. Silvopasture systems in Guatemala are an important agroforestry practice that integrates trees, forage crops and livestock to create more sustainable and productive farming systems. Silvopasture system is a type of agroforestry system which is specifically designed for integrating trees, forage and livestock on the same land. On average, households in the comparison group reported statistically significantly more often using one or more types of silvopasture systems when compared to the treatment group (see Figure 12). The most common silvopasture systems are live barriers with grass and live fences in the pasture area. The former was also mentioned above as one of the conservation practices households commonly use. When comparing the baseline to midline results, no differences are found in the average proportion of households applying the systems.

Lastly, Table 12 shows households were asked whether they cultivate trees for production, restoration or conservation purposes. On average, 26 per cent of households cultivate trees and no significant differences are found between the treatment and comparison groups. Compared to the baseline, there is a significant reduction in the proportion of households cultivating trees as the average value moved from 35 per cent to 26 per cent. The majority of households reported cultivating trees for restoration purposes.

Table 11: Climate change mitigation: Balance of Comparison vs. Treatment groups

Variable	(1)	(2)	(3)	(2)-(3)
	Total	Comparison	Treatment	Pairwise t-test
	Mean/(SE)	Mean/(SE)	Mean/(SE)	Mean difference
HH experienced some climate shock in the last 12 months	0.920	0.911	0.927	-0.016
	(0.010)	(0.010)	(0.015)	
HH members are very well or moderately informed about climate change	0.277	0.302	0.260	0.042
	(0.026)	(0.040)	(0.035)	
HH has adopted practices to mitigate climate change damage	0.916	0.899	0.927	-0.028
	(0.013)	(0.021)	(0.018)	

HH has adopted practices to mitigate climate change damage in their plot	0.821	0.797	0.838	-0.041
	(0.020)	(0.030)	(0.026)	
HH has applied some soil conservation technique	0.632	0.607	0.650	-0.042
	(0.027)	(0.037)	(0.037)	
Use improved seedlings	0.055	0.039	0.066	-0.028
	(0.013)	(0.019)	(0.018)	
N	1256	517	739	
Clusters	34	10	24	

Note: The "Total" column displays information for the entire sample. The value displayed in the last column is the mean difference based on a linear regression with standard errors clustered at the micro-watershed level. Standard errors are shown in brackets. Statistical significance is indicated by ***, ** and * at the 1%, 5% and 10% critical levels, respectively.

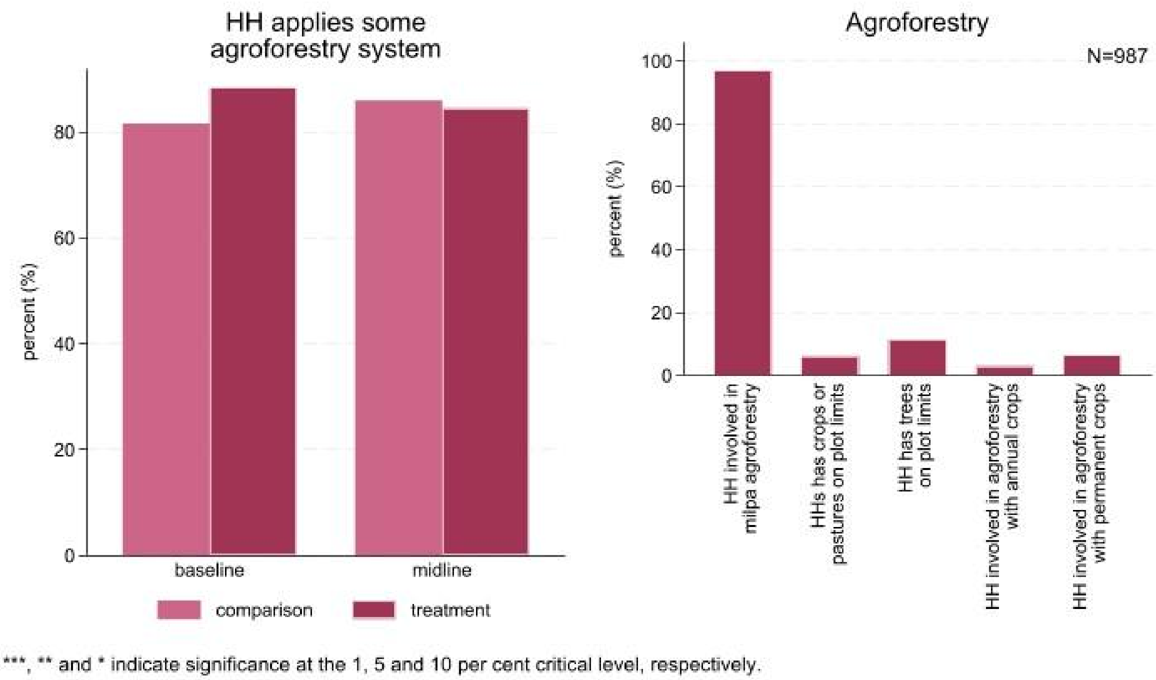
Table 12: Production: Balance of Comparison vs. Treatment groups

Variable	**(1)**	**(2)**	**(3)**	**(2)-(3)**
	Total	**Comparison**	**Treatment**	**Pairwise t-test**
	Mean/(SE)	**Mean/(SE)**	**Mean/(SE)**	**Mean difference**
Plot size total (ha)	0.212	0.196	0.222	-0.026
	(0.015)	(0.024)	(0.017)	
HH harvests annual crops	0.982	0.983	0.981	0.002
	(0.006)	(0.012)	(0.006)	
HH harvests perennial crops	0.073	0.029	0.104	-0.075**
	(0.019)	(0.013)	(0.029)	
HH applies any agroforestry system	0.852	0.860	0.846	0.015
	(0.019)	(0.020)	(0.030)	
HH applies any silvopasture system	0.324	0.407	0.266	0.141**
	(0.032)	(0.032)	(0.043)	
HH cultivates trees for production, restoration or conservation purposes	0.262	0.286	0.246	0.040
	(0.023)	(0.043)	(0.026)	

N	1159	479	680	
Clusters	34	10	24	

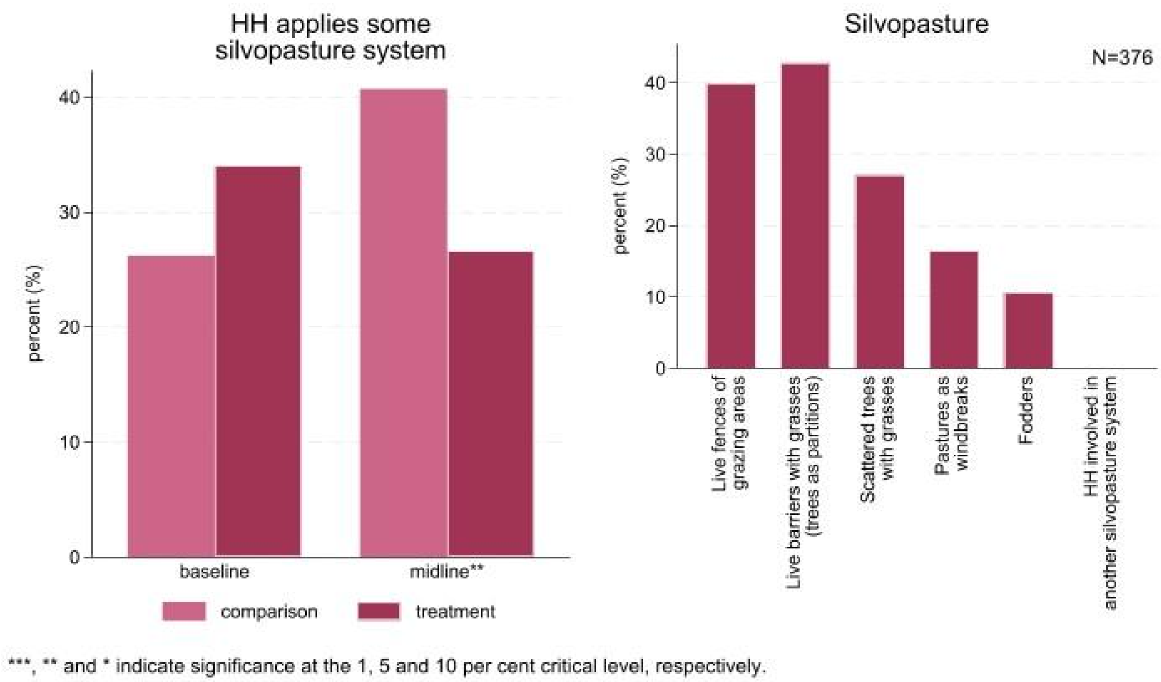
Note: The "Total" column displays information for the entire sample. The value displayed in the last column is the mean difference based on a linear regression with standard errors clustered at the micro-watershed level. Standard errors are shown in brackets. Statistical significance is indicated by ***, ** and * at the 1%, 5% and 10% critical levels, respectively

Figure 11: HHs involved in agroforestry activities by group (midline only)



Source: Own elaboration

Figure 12: HHs involved in silvopasture activities



Source: Own elaboration

EWS plays a crucial role in disaster risk reduction by providing timely information on potential climate-related hazards, allowing communities to take preventive action. These systems help mitigate the impact of extreme weather events such as hurricanes, droughts and floods by enabling better preparedness and response. However, as the findings from the Responsiveness Index show, it is evident that the existence and use of early warning systems remains very low in treatment areas. Despite their critical importance in protecting lives, livelihoods and infrastructure, limited adoption suggests gaps in accessibility, awareness or trust in these systems. Strengthening the implementation and utilization of EWS is essential to enhancing community resilience and ensuring that at-risk populations can respond effectively to environmental threats. As establishment and awareness of EWS is a key activity of Component 3 for this programme, we explore additional indicators that highlight the knowledge and use of climate information to gain a deeper understanding of their accessibility. This can provide valuable insights into how to strengthen the implementation, ensuring that more people can effectively respond to climate-related risks.

The first variable in Table 13 shows the proportion of households that know what an EWS for climate is. Compared to the baseline, the value has doubled but remains very low. Surprisingly, no statistically significant differences are present between treatment and comparison groups, suggesting a potential contamination from the awareness activities that the IUCN performs on the field (although from the monitoring data received only six observations have been slightly exposed to treatment). The little knowledge households have on EWS is also reflected on the reception of climate-related information or training on weather-related events. Only 15 per cent of households (on average) reported receiving weather information in the 12 months prior to the survey, and 11 per cent (on average) reported receiving training on weather-related events. While training has doubled from the baseline, the proportions are again relatively small considering the project started three years ago. As with the first variable, either some contamination may be occurring as the comparison group also reported receiving training, or other organizations in the area are conducting similar activities as the IUCN. In all cases, we do not observe statistically significant differences between treatment and control.

Table 13: Early Warning Systems: Balance of Comparison vs. Treatment groups

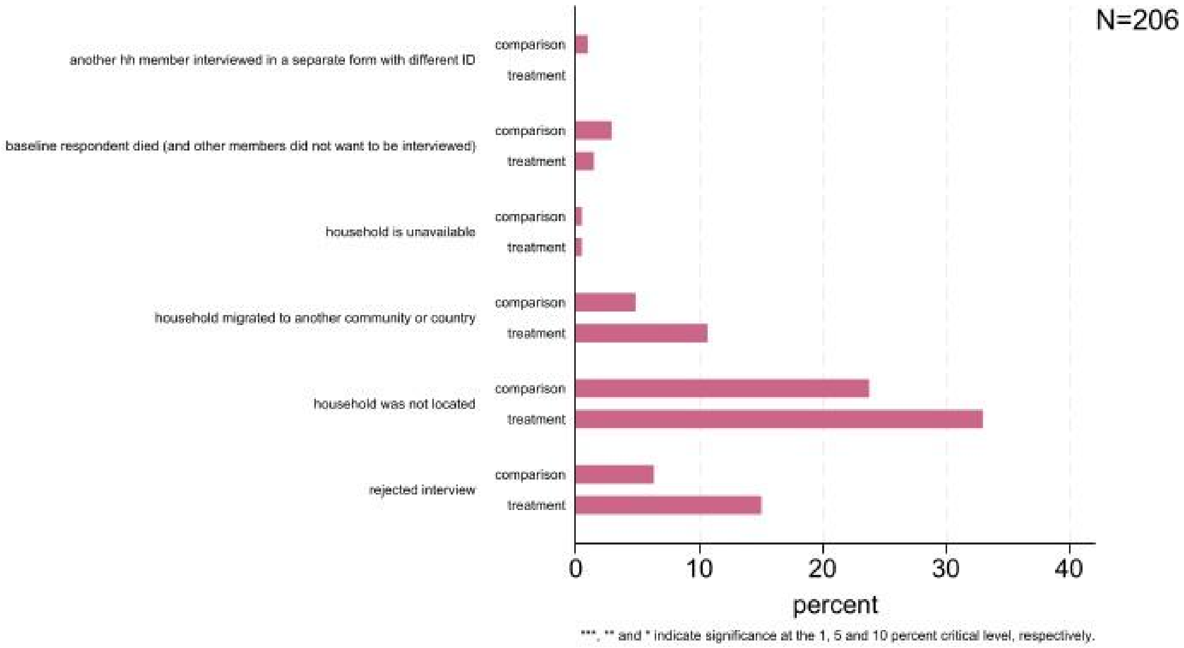
Variable	(1)	(2)	(3)	(2)-(3)
	Total	Control	Treatment	Pairwise t-test
	Mean/(SE)	Mean/(SE)	Mean/(SE)	Mean difference
HH knows what a climate EWS is	0.118	0.110	0.123	-0.013
	(0.012)	(0.022)	(0.013)	
HH received information about weather events in the last 12 months	0.150	0.133	0.162	-0.029
	(0.021)	(0.033)	(0.028)	
HH received training on weather-related events in the last 12 months	0.107	0.095	0.116	-0.022
	(0.017)	(0.018)	(0.027)	
N	1256	517	739	
Clusters	34	10	24	

Note: The "Total" column displays information for the entire sample. The value displayed in the last column is the mean difference based on a linear regression with standard errors clustered at the micro-watershed level. Standard errors are shown in brackets. Statistical significance is indicated by ***, ** and * at the 1%, 5% and 10% critical levels, respectively.

6.6.6. Robustness

In the impact evaluation, it is crucial to verify that treatment assignment does not systematically influence attrition, as differential dropout rates between treatment and comparison groups can introduce bias (i.e., selection bias due to non-observable characteristics). If households leave the project for reasons related to their treatment status, the comparability between groups is compromised, leading to potentially misleading estimates of programme effects (conditional independence assumption is threatened). The main reasons for attrition include unreachable households (57 per cent in total), rejections or unwillingness to be interviewed (21 per cent in total) or migration to other communities or countries (16 per cent in total). As shown in Figure 13, no statistically significant differences were found on the reasons for attrition. The authors would like to kindly remind the reader that besides the 206 observations, 24 households from the community "La Fe" were removed from the sample at the midline due to community leaders withholding consent for the survey. Since this decision was not made by the households themselves, these cases were excluded from the attrition analysis.

Figure 13: Reasons for lack of consent by group



Source: Own elaboration

A central identifying assumption in the Difference-in-Difference (DiD) analysis is the "parallel trends" assumption, which states that, in the absence of the intervention, the average outcomes for the treatment and control groups would have followed similar trajectories over time. While this assumption is strong and unlikely to hold unconditionally across entire groups, we instead rely on a "conditional parallel trends" assumption (i.e., that trends are parallel within subgroups defined by observable characteristics). Ensuring a covariate balance between the treatment and control groups at the baseline is therefore critical, as imbalances may indicate differing trends and compromise the validity of the DiD estimator. To address this, we conduct pre-matching diagnostics and use those imbalanced covariates as matching variables to assess how similar the treatment and control groups remain. Matching – using propensity scores based on pretreatment covariates – helps align the treatment and control groups more closely, thereby increasing the plausibility of the parallel trends assumption. Additionally, reweighting the control group using a semi-parametric specification of propensity scores can further correct for residual imbalances. While the DiD accounts for unobserved, time-invariant differences between groups, it does not control for time-varying confounders – making the combined use of matching and the DiD particularly valuable in improving the credibility of causal inference in this evaluation.

As mentioned in the Design section, a Difference-in-Difference with matching design will be used to estimate the causal effects of the programme on outcome variables, and therefore ensuring the common support is essential to guarantee that treated and comparison units have overlapping characteristics, allowing for meaningful comparisons. Common support ensures that for every treated unit, there exists at least one comparison unit with a similar propensity score which is calculated based on observable characteristics. Without it, unmatched treated observations would lack a valid counterfactual, leading to biased impact estimates. To assess the common support, density plots of propensity scores are usually assessed and trimming rules apply to exclude extreme observations (those without overlap). Enforcing the common support strengthens the credibility of the matching approach by ensuring that treatment effects are estimated only for comparable units, thereby improving the internal validity of the evaluation.

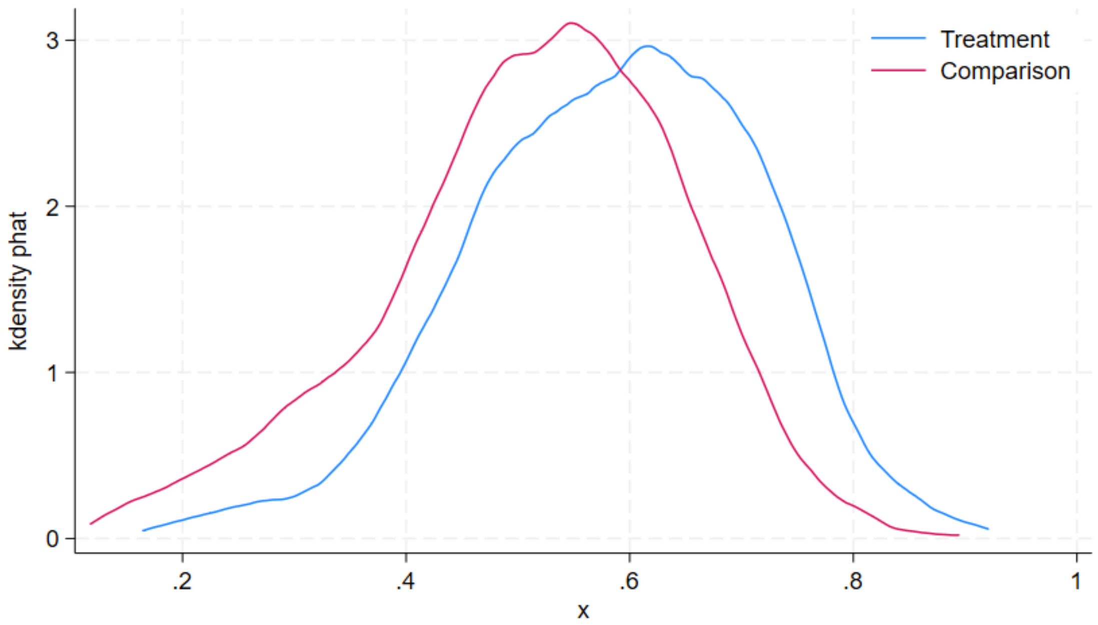
Given the balance diagnosis shown in the Results section, the variables selected to estimate the propensity scores are the following:

Table 14: Variables selected to estimate the propensity scores

Category	Variable description
Geographical location (3 variables)	Watershed dummies
Household characteristics (5 variables)	Biparental household; housing ownership; age and completion of primary education of household head; household is short on money in the last 12 months
Production characteristics (3 variables)	Land ownership; annual crops harvest; receives income from agricultural products
Climate shock related (4 variables)	Respondent believes climate change may affect them/property; household experienced climate shocks; household applies soil conservation techniques; household received climate-related information

Although it is still early to assess the common support – given the low exposure to treatment and still an expected high attrition – this exercise can already offer insights into which matching algorithms may be more efficient for the characteristics of the data. The analysis on socioeconomic characteristics, outcome variables and secondary variables above already shows some solid ground for comparability as not many statistically significant differences were found between the treatment and comparison groups. Unsurprisingly, when estimating the propensity scores and comparing the distribution of propensity scores (phat) between treated and comparison groups (see Figure 14), we find that for the most part of the distribution there is overlap between the two groups.

Figure 14: Kernel density of propensity scores



Source: Own elaboration

VII. Discussion

This midline report revisits the project's ToC, along with the evaluation questions and indicators, reflecting on three years of implementation. It also details the midline data collection process, which involved a total sample of 1,256 households across 24 treated micro-watersheds (739 households) and 10 control micro-watersheds (517 households). Considering treatment exposure, attrition and changes in the initial allocation of treatment and comparison micro-watersheds, the evaluation will continue using a Difference-in-Difference (DiD) approach with matching to ensure a rigorous assessment of the project's impact over time. However, the estimation of the Average Treatment Effects on the Treated (ATT) will be conducted at the endline, as exposure to treatment remains limited at this stage. Therefore, this midline report should be considered as purely descriptive, and no causal inferences can be drawn at this point.

The report presents baseline-midline characteristics of beneficiaries and presents the differences between treatment and comparison households in similar micro-watersheds. Besides presenting socioeconomic characteristics, climate change perceptions and land use, the report mainly centers on the differences across two key indices which are the main outcome indicators of the evaluation: (i) Resilient and Diversified Livelihoods Index and (ii) Responsiveness Index.

In terms of project implementation, the project is making significant progress toward its target of benefiting 132,000 individuals. The monitoring system is well-structured and robust, providing real-time information on project advancements. Additionally, the IUCN team consistently provides updates and maintains clear and open communication.

While this evaluation plans to use a quasi-experimental approach at the household level to ensure statistical comparability and causal inference, it is important to recognize that the project's intervention model operates primarily through community-based and watershed-level processes.

Under this approach, beneficiaries are not randomly assigned but rather self-select or are identified through community structures according to their potential and willingness to participate. What has been observed in the last years is that many of the households identified before the start of the project have either moved away or are simply not interested in participating in the project activities. Consequently, and as warned before, the initial evaluation sample collected before the start of the project may not hold until endline even when major efforts have been put in place to reach it. Given this scenario, it is likely that instead of utilizing a DiD with matching specification, the evaluation team may opt for the collection of a new sample (following the project's implementation and likely within the same identified districts and communities) and the use of a post matching design.

In addition, it is important to highlight that while the evaluation captures outcomes at the household level (such as livelihood diversification or awareness of climate risks), it may only partially reflect collective or landscape-level changes that unfold through community decision-making, governance of micro-watersheds, and ecosystem restoration. The two levels are therefore complementary: the project contributes to resilience through aggregated effects that extend beyond individual households, while the evaluation provides a consistent quantitative basis for tracking household-level dynamics over time.

VIII. Challenges and Shortcomings

We have identified six main challenges that could potentially jeopardise the successful implementation of an impact evaluation:

- Limited outreach to treatment beneficiaries: Outreach efforts to beneficiaries have been low (as of June 2024 it was 12 per cent, about 3 years after the start of the programme), impacting engagement and potentially affecting the overall outcome measurement of the intervention.
- People selling their plots: From the increased number of missing values in plot size, increased exposure to climate shocks, attrition due to migration and changes in income composition leaning towards non-agricultural income (especially for treatment households), it seems that households are either deciding to sell their land and migrate or to allocate their time and resources into non-agricultural activities. Unfortunately, questions related to land ownership were removed at the midline as it was not anticipated that such a significant number of households would no longer have their plots. As shown, household ownership still remains over 90 per cent (on average). However, given the observed changes, this question must be included in the endline data collection, together with reasons for selling the land. Not surprisingly, our results align with anecdotal evidence, arguing that farmers are selling their land and even migrating due to extreme climate shocks (e.g., increased rain, drought), as they negatively affect the productivity of their crops (see IUCN, 2024).
- Attrition within the treatment group: There has been a notable attrition rate among treatment group participants, which may reduce the reliability of the evaluation findings and impact the ability to measure the effects of the intervention. However, the attrition is still independent from treatment assignment.
- Reduction in comparison group sample size: There has been a large decrease in the comparison group sample size, which may compromise comparability and weakens the robustness of the evaluation results. It is likely that this group will further shrink at the time of the endline data collection.
- Contamination of the comparison sample: As of June 2024, we identified five households from the comparison group who had participated in project activities. Although the number is relatively low, this contamination, combined with the reduced number of comparison micro-watersheds and midline attrition, further decreases the sample size and limits the potential for a robust impact evaluation.
- Obtaining personal identification numbers: During the baseline and midline data collection, local partners encountered significant obstacles in obtaining personal identification numbers from participants, primarily due to mistrust and concerns about future data use. Although the local data collection team made extensive efforts to engage communities, explain the study's purpose and obtain permission, a substantial number of IDs remain missing. This is a critical variable needed to merge the evaluation data with the implementation data. Similar gaps appear in the monitoring data, which also complicates the merging process. To address this issue, the evaluation team used names and telephone numbers for data linkage. However, the prevalence of namesakes and the absence of many telephone numbers resulted in a lengthy and labour-intensive process with no guarantee of capturing all real beneficiaries. We identify this as a real challenge, as it is difficult to be certain which evaluation participants have been exposed to certain project interventions and the degree of such exposure (e.g., participated in 1, 2 or 4 activities).

IX. Conclusion

This document presents the midline results for the impact evaluation of the "Building Livelihood Resilience to Climate Change in the Upper Basins of Guatemala's Highlands" project. The project's overarching goal is to mitigate the impacts of climate change in the Western Highlands of Guatemala by enhancing the management of ecosystems and water resources in regional watersheds while also strengthening the capacity of households to respond to climate-related shocks. The project aims to drive a paradigm shift by focusing on maintaining the hydrological cycle, promoting water and soil management and implementing conservation practices. These practices are essential for climate change adaptation as they support restoring and providing critical ecosystem services.

The project seeks to achieve three key outcomes: Firstly, developing an integrated climate-smart watershed management system for households in prioritised watersheds. Secondly, the promotion of community-led watershed management systems through grants. Thirdly, providing climate-related information to farming households to support effective watershed management. As of 2024, the sample composition for the evaluation is 24 treatment micro-watersheds and 10 comparison micro-watersheds. The DiD combined with PSM was the most rigorous quasi-experimental approach to measure the intervention effects and test the hypotheses. Given that all activities that are part of this intervention target households, the unit of analysis for this impact evaluation is the household.

Based on the results from the midline data collection conducted between October–November 2024, a total of 1256 households have been interviewed. The observed reductions in total sample size (from 1486 to 1256), along with changes in the allocation between treatment and comparison micro-watersheds – resulting in a shift in the number of households in the treatment group (from 888 to 739) and the comparison group (from 598 to 517) – pose a significant risk to the feasibility of conducting an impact evaluation in the future.

Even though allocation changes and attrition reduced the sample composition and size quite significantly, a comparison between treatment and comparison households still reveals a high degree of similarity. Both groups exhibit comparable vulnerabilities, gaps and needs regarding resilience-building. The first index measures resilience that is essentially economic: the resilience of livelihoods for individuals who are exposed to climate shocks. The index is composed of different indicators such as poverty, access to clean water, collection of forestry products, lack of food or money due to climate shocks (vulnerability to climate change) and crop diversification. With respect to this first index, no statistically significant differences are present between the treatment and comparison groups. However, while no major changes are shown with respect to the baseline in relation to poverty, there is an increase in vulnerability to climate change and a reduction in crop diversification. This can potentially be explained by two main factors: Exposure to climate shocks has significantly increased, and households are either selling their land and migrating to other areas or moving towards non-agricultural activities.

The second index assesses both household and community capacity to recognize and respond to climate change impacts. It incorporates agricultural and natural resource management practices at the plot level, along with broader community response capabilities. Composed of four indicators, this index measures how effectively households adapt to climate risks and future shocks, also factoring in the availability and use of EWS at the community level. No statistically significant differences were found between the treatment and comparison groups at the index level or in each indicator; yet compared to the baseline findings there has been an increase in awareness, knowledge and adoption of agricultural and conservation practices to mitigate climate change effects. However, while households have improved their understanding of climate change, mitigation strategies and climate-related risks, behavioral change in utilizing EWS remains limited.

Socioeconomic characteristics are overall well-balanced, with most households earning between 1,001 and 3,000 Guatemalan quetzal (USD 120 - 360) annually. Additionally, there are no significant differences in education level or the proportion of female-headed households between the two groups. Slight differences are present in the age of the household head (older in the comparison group), number of children in the household (more children in the treatment households) and house and mobile phone ownership (higher in the treatment group).

Agricultural and conservation practices are rather similar in that most households harvest annual crops and implement at least one type of agroforestry system. Yet, some differences are found in the harvests of perennial crops (higher in the treatment group) and use of silvopasture systems (higher in the comparison group). Compared to the baseline where treatment households demonstrated higher knowledge of climate change responses than comparison households, in the midline both groups exhibit a similar high awareness and understanding of climate change events and their consequences. An important finding to highlight is the reduction of agricultural sales, land size and land tenure with respect to the baseline. One of the main drivers seems to be migration, as shown by the large proportion of baseline households that could not be reached during the midline data collection. Anecdotal evidence puts climate-related shocks as one of the main drivers for migration and for selling the land. Guatemala has been facing alternating periods of extreme drought, influenced by the "El Niño" effect and short bursts of heavy rainfall leading to flooding and landslides, caused by the "La Niña" effect. The combination of reduced rainfall and extreme temperatures has led to an increase in fire incidents on agricultural land, severely affecting farming activities. Between November 2023 and January 2024, the “El Niño” phenomenon reached its peak and the transition towards “La Niña” took longer, only starting after the second half of the year which naturally affected the planting cycle.

Since a DiD approach with matching will be used to estimate the programme’s causal effects, ensuring the common support is crucial for meaningful comparisons between the treated and comparison units. Common support guarantees that each treated unit has at least one comparable control unit based on similar propensity scores, preventing bias in impact estimates. While it is still early to fully evaluate the common support due to low treatment exposure and expected attrition, preliminary findings indicate a solid basis for comparability, with few significant differences between groups and substantial overlap in propensity score distributions.

The household-based evaluation design provides valuable insights into behavioural and livelihood outcomes, yet should be interpreted alongside community- and landscape-level evidence from project monitoring to fully capture the scope of impacts expected under the watershed management model

Overall, the project is making strong progress toward its goal of benefiting 132,000 individuals, supported by a well-structured monitoring system and clear communication from the IUCN team. However, six key challenges could affect the impact evaluation. First, outreach to treatment beneficiaries remains low (12 per cent as of June 2024), limiting engagement. Second, many households are selling their land or shifting to non-agricultural activities due to climate shocks, requiring land ownership questions to be reintroduced at the endline. Third, attrition within the treatment group and a shrinking comparison group reduce the reliability and robustness of the evaluation. Fourth, contamination in the comparison sample has been detected, with some households unintentionally participating in project activities. Finally, difficulties in collecting personal identification numbers have complicated data merging, making it harder to track participant exposure to project interventions.

9.1 Recap

The project “Building Livelihood Resilience to Climate Change in the Upper Basins of Guatemala’s Highlands” intends to target the most vulnerable micro-watersheds (those where the quality and availability of water are relatively low). We refer to these as “prioritised micro-watersheds,” whereas comparison micro-watersheds not part of the intervention area are referred to as “non-prioritized micro watersheds.” Due to the non-random selection of the treated communities, only quasi-experimental methods could be used. A combination of the DiD with the matching method was selected to evaluate the impact of the (sub-) components, as it represents a more robust method than applying either technique on its own. The baseline data collection was conducted between April and June 2021 with 1,486 subjects, from which: 758 are in the treatment group and belong to 68 villages and 21 micro-watersheds, and 728 are in the comparison group and belong to 59 villages and 14 micro-watersheds. Given the implementation updates provided in June 2024, three micro-watersheds are expected to be treated (Matuloj, Munoz and Chipacá) and therefore, the allocation of the treatment and comparison groups will use a “de facto” approach, which means that 24 micro-watersheds are now in the treatment group and 10 are in the comparison group. The additional reduction of one micro-watershed was due to the redefinition of the micro-watersheds where the Quiejel village, the only one in its micro-watershed, was found to belong to the comparison micro-watershed, Pachita.

The midline data collection was conducted between October–November 2024 and revisited 1,256 households, 739 from the treatment group and 517 from the comparison group, resulting in an attrition rate of 15 per cent from the baseline. The main reasons for attrition include unreachable households (57 per cent), rejection or unwillingness to be interviewed (21 per cent) or migration to other communities or countries (16 per cent). In addition, the community of La Fe with 24 observations was excluded from the sample altogether as the community leaders rejected the realization of data collection at this place.

Given these circumstances, the feasibility to evaluate impacts face three major challenges: First, increased changes in the composition of the treatment and comparison groups can affect the evaluation design as it reduces the likelihood of finding a sufficiently large common support. Second, the low outreach to treatment beneficiaries (only 12 per cent have been exposed to project activities) impacts engagement and likely affects the overall outcome measurement of the intervention. Third, households are selling their land due to migration or moving towards non-agricultural activities. According to the targets announced by the IUCN, the aim is to reach the treatment group in its entirety in 2025.

Despite significant reductions in sample size due to allocation changes and attrition, the treatment and comparison households remain highly similar in vulnerabilities, gaps and resilience needs. A key finding is the reduction in agricultural sales, land size and land tenure, likely driven by migration, as climate-related shocks – such as extreme drought from "El Niño" and heavy rains from "La Niña" – have severely impacted farming activities.

As one of the main assumptions for the matching design is the common support, the midline report includes a short exercise on it. Although it is too soon to fully assess the common support due to low treatment exposure and anticipated attrition, the initial results suggest a strong foundation for comparability, with few notable differences between the groups and significant overlap in the distribution of propensity scores.

Appendix 1: Evaluation Questions

Evaluation Question	Midline Answer (Descriptive)
Main EQ1 – To what extent have farmers achieved more resilient and diversified livelihoods? (C1.1, C2.1)	• No observable differences between treatment and comparison groups in the Resilient & Diversified Livelihoods Index. • Agricultural diversification declined overall, linked to climate shocks and land sales. • Vulnerability increased, mainly due to climate events and reduced agricultural revenue.
Main EQ2 – To what extent are farmers less vulnerable to extreme weather events? (C3)	• Responsiveness Index shows no differences across groups. • Households show increased awareness of climate risks but limited behavioural change in using Early Warning Systems (EWS). • Climate shocks ("El Niño", "La Niña") continue to severely impact production, suggesting ongoing vulnerability.
Secondary EQ1 – Has multidimensional poverty changed? (C1.1, C2.1)	• No differences between groups in the multidimensional poverty sub-components (education, life quality, assets, food security). • Overall poverty levels remain high and unchanged.
Secondary EQ2 – Has access to and quality of water improved? (C1.1, C2.1)	• No differences between groups in water access or water quality indicators. • Overall water conditions remain similar across the sample
Secondary EQ3 – Has vulnerability to climate change reduced? (C1.1, C2.1)	• Climate vulnerability increased, with more households reporting climate-related impacts. • No advantage for treatment households, given low exposure.
Secondary EQ4 – Has income and crop diversification increased? (C1.1, C2.1)	• Income sources shifted, with many reporting declines in agricultural sales. • Crop diversification decreased, partly due to climate shocks and land loss. • No differences between groups.
Secondary EQ5 – Has awareness and knowledge of climate-smart agriculture improved? (C1.1, C2.1)	Increased awareness of soil conservation and conservation practices, but trends are similar for both groups (not attributable to treatment).

Secondary EQ6 – Are farmers better informed about climate change risks and EWS? (C3)	• EWS awareness increased, but use remains low. • No differences between treatment and comparisons (consistent with only 12% coverage).

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