ECOSYSTEM-BASED DISASTER RISK REDUCTION and COMMUNITY RESILIENCE IN HAITI

A COST-BENEFIT AND EQUITY ANALYSIS

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Citation:
Vicarelli, Marta, Anamaria Georgescu, Kerry Judge, Asiel Arroyo, Htike Htike Aung, Jennifer Nelson, Jessica Mooring, Nujhat Purnata, Yin Yin Win, 2022. “Ecosystem-based Disaster Risk Reduction and Community Resilience in Haiti: a Cost-Benefit and Equity Analysis” University of Massachusetts Amherst, MA, USA.

June 21, 2022

Above: Sensitization campaign organized by Youth Haitian Red Cross in the community of Tiburon (Photo credit: Haitian Red Cross).

Cover image: Reforestation and tree nursery initiative in Haiti (Photo credit: Haiti Red Cross).

Report prepared by a team of researchers from the **University of Massachusetts Amherst** with the support of the **United Nations Environment Programme (UNEP)**, and the **Partners for Resilience (PfR)**, and **the European Union**. PfR includes the following organizations: CARE, Cordaid, Climate Centre, Netherlands Red Cross, and Wetlands International.

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We are grateful to the United Nations Environment Programme (UNEP) and Partners for Resilience (PfR) for their partnership during the project.

Special thanks to Malikah Amril, Field Project Coordinator, Eco-DRR at UNEP; Julia Velez Ardaiz, Project Management Delegate for Climate and Resilience at the Netherlands Red Cross; Vincent van Haaren, Program Manager for Ecosystem-based DRR at the Netherlands Red Cross; and Dr. Karen Sudmeier-Rieux, Senior Advisor for Disaster Risk Reduction at UNEP.

This report is part of a series of four reports analyzing the UNEP and PfR Eco-DRR interventions in Haiti, India, Indonesia, and Uganda.

Haiti:
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Uganda:
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EXECUTIVE SUMMARY

This study performs an economic efficiency and equity analysis of an Ecosystem-based Disaster Risk Reduction (Eco-DRR) and resilience enhancement intervention in Haiti. Disasters resulting from natural hazards pose an increasing threat to human health and safety, livelihoods, and economies. Their impacts are expected to worsen with climate change. Nature-based solutions are emerging as possible strategies to mitigate disaster risk; however, more research is needed to assess the economic efficiency and equity of Eco-DRR activities in strengthening community resilience. The aim of this study is to contribute to this growing literature.

We examine the project "*Up-scaling Community Resilience through Ecosystem-based Disaster Risk Reduction*" implemented by the United Nations Environment Programme (UNEP) in collaboration with Partners for Resilience (PfR), a global coalition between the Netherlands Red Cross, the Red Cross/Red Crescent Climate Center, Cordaid, Wetlands International, and CARE Netherlands. The project, started in 2018 and completed in June 2022, supported Eco-DRR efforts in Uganda, Indonesia, India, Haiti, and Ethiopia. In this study we examine the Haiti intervention. The portfolio of Eco-DRR and resilience enhancement activities in Haiti focuses on community-based forest ecosystem restoration and management; improved flood and landslide hazards response preparedness; and training and support for sustainable livelihood development. Leveraging the engagement of 43 community-based organizations, the Eco-DRR project target is to make 70,000 people resilient to disasters and climate change, chronic food insecurity, and land degradation.

We performed an **economic efficiency assessment** of the project through a quantitative Cost-Benefit Analysis and a qualitative analysis that considers non-monetary benefits too. Our quantitative estimates show that the benefits of the Eco-DRR and resilience enhancement interventions outweigh the value of their initial costs, with the present value of net benefits up to $5,453,427.33 USD after 10 years since the project implementation. Our qualitative analysis complements these findings presenting a rich bouquet of long-lasting benefits associated with the Eco-DRR strategies, ecosystem management, and sustainable livelihood practices implemented during the project. Lastly, our **equity assessment** indicates that the project promotes equity by enhancing inclusivity, economic equality, participation, and capacity building. In particular, the resilience interventions implemented result in significant education, health, safety and economic improvements for women, children, and economically vulnerable members of the local communities. As part of this study our research team also organized a **learning workshop** with local project partners to share detailed information about the methodological approach used and the results of our analysis. The final goal of the workshop is ensuring that the project partners will be able to (i) reproduce equity and efficiency assessments for future interventions; and (ii) communicate those findings to local and regional stakeholders to promote policies that further disaster risk reduction and community resilience.

INTRODUCTION

This study performs an economic efficiency and equity analysis of an Ecosystem-based Disaster Risk Reduction (Eco-DRR) and resilience enhancement intervention in Haiti. Eco-DRR is defined here as "the sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim to achieve sustainable and resilient development" (Estrella & Saalismaa, 2012).

Disasters resulting from natural hazards pose an increasing threat to human health and safety, livelihoods, and economies. The consequences of disasters are only expected to rise, as the impacts of climate change worsen (IPCC, 2022). Although there is some evidence that strengthening ecosystem services is a cost-efficient approach to address certain natural hazards (Sudmeier-Rieux et al., 2021), more research is needed to assess the economic efficiency and equity of Eco-DRR activities in strengthening community resilience. The aim of this study is to contribute to this growing literature.

We examine the project "Up-scaling Community Resilience through Ecosystem-based Disaster Risk Reduction" implemented by the United Nations Environment Programme (UNEP) in collaboration with Partners for Resilience (PfR), a global coalition between the Netherlands Red Cross, the Red Cross/Red Crescent Climate Center, Cordaid, Wetlands International, and CARE Netherlands. The project started in 2018 and was completed in June 2022. Since its inception, the participating organizations have scaled up prior Eco-DRR efforts and promoted large-scale adoption of Eco-DRR through a series of professional training and pilot projects in Uganda, Indonesia, India, Haiti, and Ethiopia. The interventions are tailored to each location's unique ecosystems and respond to the specific disaster risks faced by participating communities.

The portfolio of Eco-DRR and resilience enhancement activities in Haiti focuses on strengthening the integrated risk management approach in three municipalities in the Sud Department: Les Chardonnières, Les Anglais, and Tiburon through community-based forest ecosystem restoration and management; improved flood and landslide hazards response preparedness; and training and support for sustainable livelihood development. The project target is to make 70,000 people resilient to disasters and climate change, chronic food insecurity, and land degradation through the teaching of sustainable agricultural practices, support of 43 community-based organizations with Eco-DRR activities, and restoration and preservation of 56 hectares (ha[1]) of ecosystems[2].

This study evaluates the economic efficiency of the Haiti project using a Cost-Benefit Analysis to compare implementation costs with observed and future benefits. We also perform an equity assessment, examining the distribution of benefits among the people affected by the intervention with a particular focus on women, children and vulnerable socio-economic groups. The remainder of the report is organized as follows: Section 1 describes the key features of the Eco-DRR intervention in Indonesia; Section 2 outlines the methodology used in the Cost-Benefit and Equity Analyses; Section 3 presents and analyzes the results; and Section 4 concludes.

1 - "Hectares" is indicated as "ha" throughout the report.

2 - These figures reflect the intervention progress of April 1, 2022. The project might have progressed further since this date.

1. BACKGROUND

Healthy ecosystems and availability of ecosystem services are crucial to communities' ability to reduce disaster risks and adapt to the impacts of climate change, as is recognized by several international frameworks and agreements (CBD, 2014; UNISDR, 2015). Ecosystem services are the range of goods and benefits that communities derive from ecosystems (Millennium Ecosystem Assessment, 2005). In terms of disaster risk reduction, research supports the ability of healthy ecosystems to reduce vulnerability to hazards by supporting livelihoods, while acting as physical buffers to reduce the impact of hazard events (Renaud et al., 2013; Wheeler et al., 2016).

1.1 Country Profile

Haiti is a Caribbean country that shares the island of Hispaniola with the Dominican Republic to its east. Haiti has a tropical climate and is mountainous, with scrub, conifers, and mangrove forests as its main vegetation cover. Haiti's population of nearly 12 million is growing at an annual rate of 1.34% (Haitian Institute of Statistics and Informatics, 2021). Haiti's economy is primarily agriculture-based, with 70% of Haitians earning a livelihood through small-scale subsistence farming (UN Development Programme, 2022). 80% of the population is estimated to live in poverty. Haiti's national GDP per capita is $2,925 USD (World Bank, 2021) and its Human Development Index is 0.51, ranking Haiti 170 out of the 189 ranked nations/regions (United Nations Development Programme, 2020).

Haiti's geological, topographical, and climatic conditions expose it to a wide range of hazards and cyclones (e.g. storms and hurricanes), floods, landslides and earthquakes (World Bank, 2021). Floods represent the greatest threat (World Bank, 2022). Widespread deforestation coupled with poor drainage infrastructure, creates an environment conducive to flooding. When it rains, the steep, often barren hills flush rainwater toward the urban areas in the valleys (World Bank, 2022). High poverty levels, unreliable infrastructure, and unstable governance compound these threats to make Haiti particularly vulnerable, resulting in 96% of Haitians being exposed to two or more of these hazards (ACP-EU Natural Disaster Risk Reduction Program, 2017).

Human-driven environmental threats such as deforestation and soil erosion due to charcoal production are a result of severe poverty and lack of governance experienced by Haitians, but also exacerbate disaster risk by damaging ecosystems' ability to buffer the impacts of hazards (USAID, 2020). This also creates poverty traps as Haiti's primarily subsistence-based economy suffers from unhealthy soil and poor crop production (USAID, 2020). The frequency and level of vulnerability to disaster risk has a high cost for Haiti, with average annual losses from disasters estimated to be between 8% (UNDDR, 2020) to 17.5% of GDP annually (Centre for Research on the Epidemiology of Disasters and UNISDR, 2018). Haiti's disaster risk associated with extreme precipitation is expected to intensify with climate change.

In a recent example of the magnitude of human and economic loss associated with disasters in the communities targeted by this project, in 2016 Hurricane Matthew hit the South District and affected over 2 million people, resulting in over 500 deaths and displacement of 175,000 Haitians. Losses and damages were estimated at 32% of the nation's 2015 GDP (World Bank, 2020). More recently, in August 2021, a 7.2 magnitude earthquake shook the same region, causing 2,248 deaths and 12,763 injuries. 329 people remain missing as of 2022. The earthquake destroyed 53,815 houses and 83,770 public buildings with losses totaling approximately $1.11 billion USD (International Federation of Red Cross, 2021; World Bank, 2021).

1.2 Eco-DRR intervention

UNEP and a PfR team (including the Netherlands Red Cross, Haitian Red Cross) developed and implemented Eco-DRR and community resilience interventions in Haiti's Sud Department in the municipalities of Chardonnières, Tiburon, and Les Anglais, shown in Figure 1.

UNEP and PfR use the Eco-DRR Resilience Triangle Framework to set Eco-DRR goals and measure progress of their interventions toward vulnerability reduction and community resilience building (Figure 2). The Eco-DRR Resilience Triangle features three components: Disaster Risk Reduction, achieved through environmental restoration; Ecosystems Management, achieved through protective measures and community awareness campaigns; and climate change adaptation and sustainable socio-economic growth through the promotion of Sustainable Livelihood Practices.

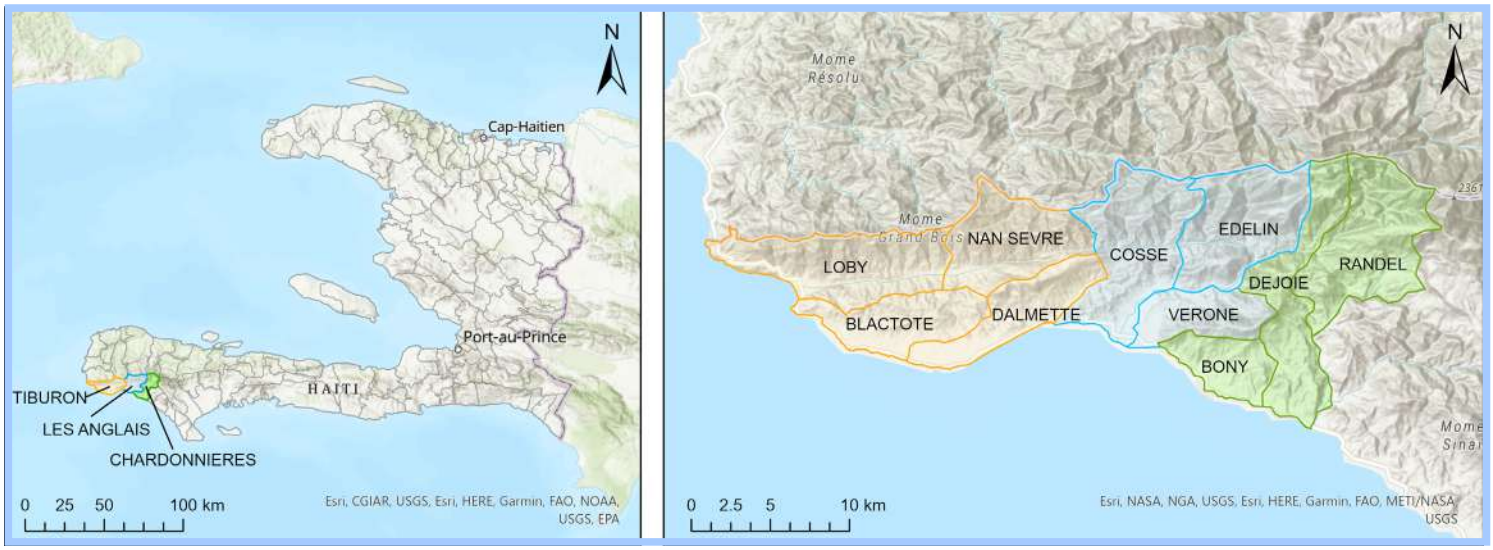


Figure 1. Location of the project area in the South District of Haiti. The Eco-DRR Resilience interventions were implemented in three municipalities: Les Chardonnières, Les Anglais, and Tiburon, engaging 43 community-based organizations, and aimed at increasing resilience for 70,000 residents.

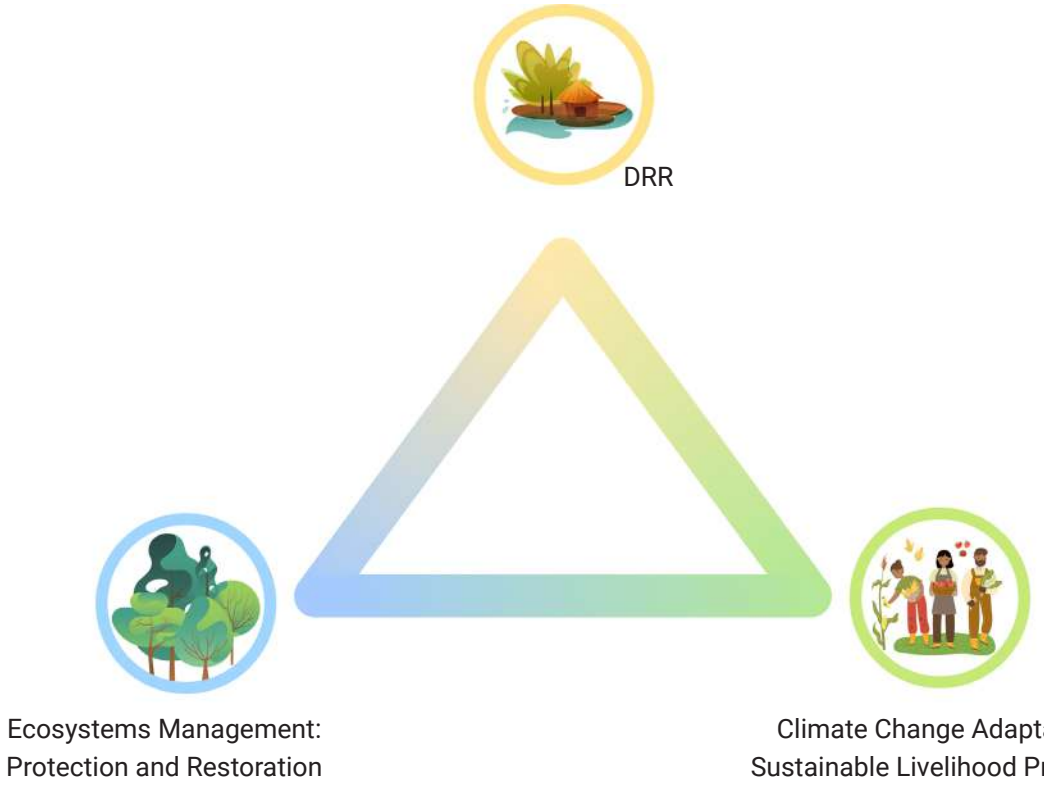


Figure 2. This figure shows the three dimensions of the Eco-DRR Resilience Triangle Framework implemented to achieve community resilience: Disaster Risk Reduction (DRR); Ecosystems Management, Protection and Restoration; and Climate Change Adaptation through Sustainable Livelihood Practices. This study uses this framework to analyze and catalog the benefits of the Eco-DRR interventions.

The interventions in Haiti focus on reducing risks to the ecosystem and surrounding communities through an integrated approach of reforestation, engineering-based infrastructure, training on erosion prevention, and hazard response preparedness. Community resilience is further enhanced by supporting local economic development through the adoption of sustainable livelihood practices. This portfolio of activities includes training and support for apicultural activities; promotion of *jaden lakou* (i.e., vegetable gardens) and petit commerce for local women; and training in sustainable and climate smart agricultural practices. Specific details of these activities are provided in Figure 3.

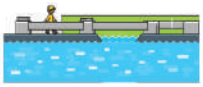
In addition to the activities listed above, which frame the scope of our efficiency assessment, the interventions also have been building communities' capacity to engage with local and district authorities through bottom-up planning, awareness raising, community mobilization activities, and sensitization of youth to disaster risk and climate change. These stakeholder engagement and capacity building strategies are examined in the equity assessment portion of our analysis.

Photo credit: Haiti Red Cross

A Haitian Red Cross volunteer engaged in a reforestation sensitization campaign in the community of Tiburon.

Photo credit: Haiti Red Cross

A youth volunteer for the Haitian Red cross during an Eco-DRR sensitization training.

INTERVENTIONS	BENEFITS		
	DRR	Ecosystems management	Sustainable livelihoods
REFORESTATION • Erosion Prevention through reforestation and planting of high value vegetation using Slope Agriculture Land Technology (SALT) • 56 ha of degraded mountain land restored with native tree species • reinforcement of agroforestry and woodlot, and creation of natural zones • Environmental Impact Monitoring in joint coordination with the Sud department branch of the Ministry of Environment 	✓	✓	✓
ENGINEERING-BASED INFRASTRUCTURE • Building check dams, gabions, retaining walls and contour bunds • Erosion, landfall and landslides prevention interventions 	✓	✓	✓
TRAINING ON EROSION PREVENTION • Awareness raising and skill training on Erosion Prevention • Youth-led sensitization in schools 	✓	✓	✓

HAZARD RESPONSE PREPAREDNESS
• Capacity Building and skills training for HRC* staff and volunteers, local authorities, CBOs** (reached 30 local HRC volunteers)
• VCA and Commune Action Planning (four days in each area)
  • to understand risks, exposure, resources and opportunities
• Development of Early Warning and Early Action mechanisms
  • for planning anticipatory DRR and response preparedness action
• Multimedia Awareness Raising campaign by using
  • theatre, games in schools, billboards, videos, talks, radio broadcasting and (radio) contests 
	✓	✓	✓

APICULTURAL ACTIVITIES • Enhancement of commercial apicultural activities • Improved ecosystem management of sites surrounding apicultural activity • Distribution of apiary materials and 20 modern beehives 		✓	✓

JADEN LAKOU (i.e., VEGETABLE GARDENS)
• 8 community women groups trained and engaged in vegetable gardening for livelihood strengthening
• 8 model gardens developed with women groups to practice new techniques and showcase results
  • one horticultural/cereal garden for every house
  • production used for consumption and for sale (extra revenues) 
			✓

SUSTAINABLE AGRICULTURE
• Bioculture training focusing on
  • use of local nursery site plants, crop production and composting
  • 43 CBOs reached, including local women groups and Red Cross
• Distribution of agricultural inputs (e.g. seeds and tools) 
		✓	✓

*HRC Haiti Red Cross; CBO** community based organization;

Figure 3. This figure shows the Interventions adopted in Haiti and their benefits cataloged based on the three dimensions of the Eco-DRR Resilience Triangle: Disaster Risk Reduction (DRR); Ecosystems Management, Protection and Restoration; and Climate Change Adaptation through Sustainable Livelihood Practices.

2. METHODOLOGY

The methodological approach adopted in this study includes five components: desk research, data collection, Cost-Benefit and Equity Analysis, creation of learning materials, and knowledge sharing (Figure 4).

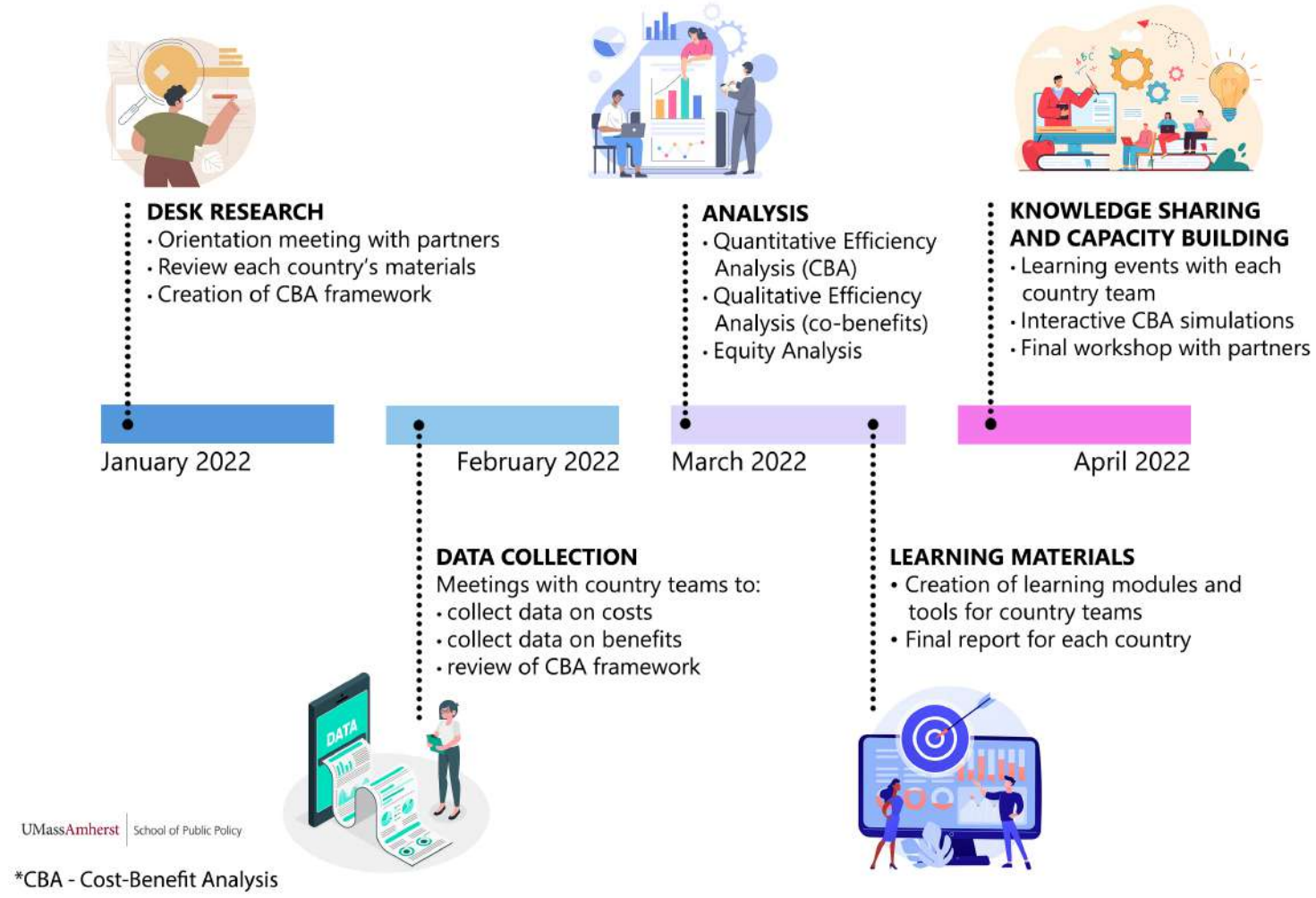


Figure 4. Project timeline and methodological approach adopted in performing the Efficiency and Equity analysis.

2.1 Desk Research

Following the kick-off orientation meeting with Haiti's project coordinators, the research team conducted an in-depth review of the project materials (including budgets, progress summaries, case studies, and success stories) provided by the project partners. This background review led to a detailed itemization of the project implementation costs, and the creation of a preliminary catalog of intervention benefits. The data collected includes both monetary values and qualitative information. The design of the Cost-Benefit Analysis framework used in this study builds on this preliminary data.

2.2 Data Collection

A set of meetings with Haiti's project coordinators allowed the research team to review and refine the analytical framework and collect additional data on the project's costs and benefits. In agreement with our Haiti project partners, the scope of our analysis focuses on the costs directly associated with Eco-DRR implementation, ecosystem restoration and protection, and sustainable livelihood development. Administrative and planning costs are not included in the cost-benefit estimations. The rationale for this approach is that in order to identify and quantify environmental and social benefits resulting from the Eco-DRR interventions, considered costs should be limited to the direct costs of the interventions. Other costs such as administrative and planning costs, while significant, are transaction costs and not direct costs of Eco-DRR implementation.

In addition to reviewing and approving the monetary values of costs and benefits to be included in the framework, the Haiti project partners provided background information about local property values, average annual income, and number of households (and total number of people) benefiting directly or indirectly from the project. Project partners visited project sites and collected additional data through interviews with local stakeholders. Working closely with the Haiti country team we were able to collect abundant qualitative information on environmental and socio-economic benefits that could not (at least at this stage) be expressed in monetary terms (e.g., empowerment of women and girls, increase in biodiversity). The analysis of these rich qualitative data is an important part of this study, as it complements the quantitative cost-benefit assessment and contributes to the equity assessment. Examining the duration of benefits after the project implementation is an important dimension of our analysis. The project partners confirmed the exact locations associated with each cost and benefit in our database, and indicated their respective time horizons (i.e., time when costs/benefits began and their expected duration into the future). Testimonials and quotes from beneficiaries provide an additional layer to our analytical framework. A selection of quotes is included in the qualitative results section of this report.

2.3 Data Analysis

The data analysis and the deliverable generated are outlined in Figure 5. The deliverables include:

1. **Quantitative Economic Efficiency Assessment** - We study the economic efficiency of the Eco-DRR and community resilience interventions by completing a Cost-Benefit Analysis (CBA). The CBA compares the available monetary values of costs and benefits andis described in more detail below.
2. **Qualitative Economic Efficiency Assessment** - This qualitative analysis complements the quantitative assessment. It analyzes the abundant qualitative data on environmental and socio-economic benefits gathered from interviews with field-staff and feedback from local stakeholders.
3. **Equity Assessment** - We examine the resilience interventions along the following equity dimensions: inclusivity, economic equality, participation, and capacity building. This equity assessment complements the economic efficiency assessment by providing insights into redistributional aspects of the interventions: the distribution of benefits among local stakeholders and the broader impacts of the interventions on beneficiaries' lives.

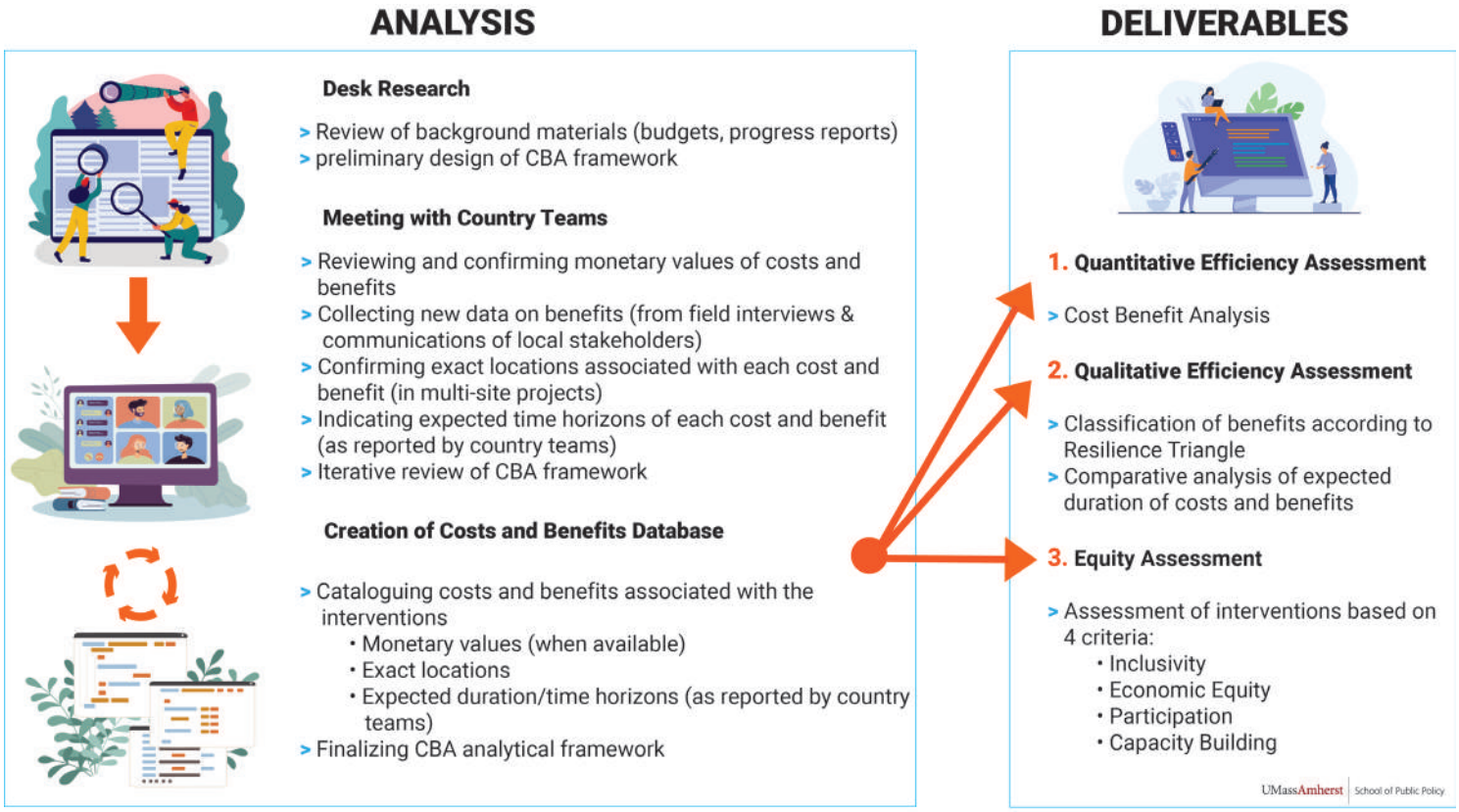


Figure 5. This figure shows the three steps of our data analysis protocol and the three deliverables: (1) the Quantitative component of the Efficiency Assessment, (2) the Qualitative component of the Efficiency Assessment, and (3) the Equity Assessment.

Part I. Quantitative Efficiency Assessment: Cost-Benefit Analysis

Cost-benefit Analysis (CBA) allows the comparison of the *net benefits* (expressed in monetary values) of different policy scenarios over time. *Net benefits* are the difference between benefits and costs and represent a measure of *efficiency*. Discounting techniques allow us to aggregate costs and benefits occurring at different times into the future. The present value of net benefits is referred to as Net Present Value (NPV). When comparing two policies, the most efficient policy is the one with the highest present value of net benefits (NPV) over a given time period.

The CBA framework adopted in this study examines the net benefits of the Eco-DRR intervention over 10 years, compared to a baseline scenario where there is no Eco-DRR intervention. Our estimations are performed using three discount rates (i.e., 3%, 7%, and 10%) to allow for robustness checks. The discount rates adopted are recommended by the US Office of Management and Budget (OMB)[3] (Congressional Research Service, 2016; Li, Q. and Pizer, W.A., 2021). In our analysis we compare two alternative Eco-DRR scenarios (with a different range of benefits) to the baseline scenario (corresponding to no Eco-DRR intervention):

3 - The 7 percent rate captures the return paid by private capital, it reflects effects on investment and business. The 3 percent rate represents the return received by consumers, with the difference due largely to taxes (Li, Q. and Pizer, W.A. 2021).

Baseline Scenario: no Eco-DRR intervention

Scenario 1: Eco-DRR intervention
- Benefits include reduction in property damages and income losses
- Benefits **do not** include carbon capture and pollution reduction

Scenario 2: Eco-DRR intervention
- Benefits include reduction in property damages and income losses
- Benefits include carbon capture and pollution reduction

Part II. Qualitative Efficiency Assessment

The qualitative efficiency analysis complements the quantitative assessment by considering all socio-economic and environmental benefits and co-benefits, including those which cannot be expressed as monetary values. Some benefits described through internal background documents or communicated by our project partners, although still pertinent to the project efficiency and equity analysis, are not quantifiable in monetary terms (e.g., more reliable access to education, empowerment of women and girls, increase in biodiversity)[4]. However, they provide valuable insights into the vast array of positive externalities generated by the intervention. We analyzed them using the Eco-DRR Resilience Triangle Framework (presented in Figure 2). We organized all benefits identified by local partners (i.e., both qualitative and quantitative data) based on the three framework dimensions: DRR, Ecosystems Management, and Sustainable Livelihood Practices. These categories provide a high-level overview of the expected benefits of the interventions. Our analysis was finalized by identifying for each category of benefits their contribution to specific social, economic, and environmental outcomes including risk reduction, avoided damages, increased wages and revenues, water security, gender equality, health, and education.

Part III. Equity Assessment

The equity assessment consists of a qualitative analysis of how the project meets the following criteria: inclusivity, economic equality, participation, and capacity building (Figure 6). Special attention is paid to the impact of the interventions on vulnerable groups, in particular women and children. The equity assessment was completed by reviewing project documentation and discussing with project partners the environmental and economic consequences of the interventions.

4 - These benefits cannot be measured given the time and data available for this project but could potentially be estimated in the future if more time and resources were available for data collection.

Figure 6. The four dimensions of the Equity Assessment of the Eco-DRR resilience intervention implemented in Haiti.

2.4 Creation of Learning Materials

Following the data analysis, the research team created learning materials for the project partners to familiarize with the analytical framework adopted and ultimately be able to reproduce the analyses in future projects.

Learning materials created for the project partners include:

1. Final Cost-Benefit Analysis framework, including cost-benefit calculations, with benefits categorized and aggregated based on the Resilience Triangle categories.
2. Annotated template of the Cost-Benefit Analysis framework that project partners can use to update the analysis as the project develops, or to conduct independent analyses of future projects.
3. Slides describing the analytical approach and study results in detail (to be used for internal training purposes or local knowledge dissemination).
4. Final report including project overview, methodological approach, analysis, and results.

2.5 Knowledge Sharing and Capacity Building

The final step in our methodological approach is sharing with project partners the knowledge produced through the research team's analyses. The final goal is for project partners to build upon and replicate this work in support of future projects.

To achieve this objective, the research team has designed and organized a Learning Workshop with the project partners to present the results of the analysis, provide a detailed description of the methodological approach (including tips and best practices for future reproduction of the analytical framework), engage with project partners in Cost-Benefit Analysis simulations, and answer the team's questions. The purpose of this learning exercise is to ensure that the project partners will be able to estimate the efficiency and equity implications of future interventions and communicate those findings to local and regional stakeholders to promote policies that further disaster risk reduction and community resilience.

3. ANALYSES AND RESULTS

The results of the efficiency assessment are provided below, followed by the results of the equity assessment.

3.1 Efficiency Assessment: Cost-Benefit Analysis

Implementation Cost - Budget documents provided by the country teams show that the cost of the intervention associated with *Community-based Eco-DRR Planning* and *Ecosystem Restoration and Protection* activities amount to 218,316 USD (Appendix 1). We assume no maintenance after the end of the project implementation (June 2022).

Benefits - Future benefits of the Eco-DRR and community resilience interventions will include reduction in risk of floods and landslides. This could in turn reduce damages to properties and income. The benefits estimated in the Cost-Benefit Analysis (CBA) calculations include reduction in property damage and reduction in GDP per capita losses (e.g., income loss) from avoided hazards, as well as carbon sequestration and pollution mitigation (Table 1).

- **Reduction in property damages from avoided hazards** - reduction in risk of floods and landslides is expected to lead to mitigation of damages to destruction of farmland and dwelling places. We estimated the total values of properties in the project area as follows:

    - Total number of people in the project area: 22,333 people
    - Homes/properties in the project area (6 people per household): 3,722 properties
    - Property prices: (average approximately) 10,000 USD
    - Estimated total property value in the project area = 10,000*3,722 = 37,220,000 USD

- **Reduction in income losses from avoided damages** - In 2020, Haiti GDP per capita was 2,925 USD (World Bank data). The total population in the project area is 22,333 people. We assume that 1/3 of local residents work, the remainder are retired, too young or unemployed.
    - Estimated total annual GDP in the project area = 2,925*(22333/3) = 21,774,675 USD

As previously mentioned, the major natural hazards that threaten Haiti are cyclones, floods, droughts, and landslides, with floods leading as the greatest threat and contributor to vulnerability (World Bank, 2022). Haiti's economic losses from natural hazards as % of GDP between 2000 and 2019 correspond to 8%. These losses account also for the large 2015 earthquake (UNDDR, 2020). In our analyses, we conservatively assume a 2% yearly loss in properties and GDP per capita in the project area. Climate conditions are expected to worsen with climate change, therefore we perform robustness checks applying a 5% yearly loss in properties and GDP per capita in the project area (available upon request). We assume that the Eco-DRR intervention will be able to reduce flood risk and mitigate losses.

Carbon sequestration and pollution mitigation are also included as benefits in our estimation. The software iTree Canopy is a global forestry analysis and benefits assessment tool from the United States Department of Agriculture's (USDA) Forest Service. iTree allows to calculate carbon sequestration and storage as well as pollution reduction of a given vegetation area, selected via Google Map. The 56 ha of land reforested in Haiti is estimated to sequester roughly 223.65 tons of carbon annually, and the overall carbon storage capacity for the same area is estimated at 2,928.81 tons (Appendix 3). iTree provides estimates of the corresponding monetary values too, and we used them in the CBA calculations (Table 1).

- **Carbon stored in trees** - 2,928.81 tons. The carbon stored in the reforested area (56 ha) is not an annual benefit, it is a one-time benefit reached at maturity of the forest, after 5 years.
- **Carbon sequestered thanks to Eco-DRR reforestation efforts** - 223.65 tons per year. The surface currently reforested is 56 ha.
- **Pollution reduction thanks to Eco-DRR reforestation efforts** - 4,436.57 kg per year. The surface currently reforested is 56 ha. Pollutants reduced correspond to Carbon Monoxide, Nitrogen Dioxide, Ozone, Sulfur Dioxide, Particulate Matter less than 2.5 microns, Particulate Matter greater than 2.5 microns and less than 10 microns.

Scenarios - The CBA framework adopted compares the Net Present Value (i.e., Present value of Net Benefits) after the intervention with a baseline scenario (i.e., no intervention). We consider two scenarios that include a different range of benefits:

Scenario 1 - Eco-DRR intervention

- Benefits include reduction in property damage and income losses
- Benefits do not include carbon capture and pollution reduction

Scenario 2 - Eco-DRR intervention

- Benefits include reduction in property damage and income losses
- Benefits include carbon capture and pollution reduction

BENEFITS					
			SCENARIO 1	SCENARIO 2	
year		Maximum Loss	USD (3/29/22)	USD (3/29/22)	source
1	**reduction in property damages** from avoided hazards (annually)	37,220,000.00	744,400.00	744,400.00	information about property values was collected by country team
2	**avoided income losses** reduction of losses from business interruption (annually)	21,774,675.00	435,493.50	435,493.50	GDP per capita (World Bank, 2020)
3	**carbon stored in trees** (this benefit is not an annual rate)			245,392.00	benefits are estimated using the program iTree
4	**carbon capture and sequestration** (annually)			18,760.00	benefits are estimated using the program iTree
5	**other pollution reduction** (annually)			21,611.14	benefits are estimated using the program iTree
		58,994,675.00	**1,465,656.64**	**1,179,893.50**	-

Table 1. Benefits included in the Cost-Benefit Analysis calculations under Scenario 1 and Scenario 2.

Assumptions - The Cost-Benefit Analysis framework adopts the following assumptions and specifications:

- The present value of net benefits (i.e., Net Present Value, NPV) is estimated over a time horizon of 10 years from the end of the project implementation)
- The full costs of the project implementation are paid only once in year 0, which corresponds to the end of the implementation
- The ecosystem associated with the eco-DRR intervention (i.e., forest) reaches maturity after 5 years
- There is a 2% yearly loss in properties and GDP per capita in the project area (we also perform robustness check with a 5% yearly loss)
- Until year 5, while the ecosystem is maturing, there is a progressive increase in benefits (i.e., 10% of benefits the first year, 20% the second year, 30% the 3rd year, 40% the 4th year and 50% the 5th year)
- The ecosystem restored/protected by the eco-DRR intervention reaches maturity after 5 years, and starting in year 6 it provides full benefits.

Discount rates - The CBA estimations are performed using three discount rates (i.e., 3%, 7%, and 10%) to allow comparisons across outcomes and robustness checks. Higher discount rate values lead to a lower weight of future benefits and costs in the CBA estimation. Ecosystem-based interventions may generate long-term benefits that might be underestimated with high discount rates. For this reason, it is important to adopt a range of discount rates and perform sensitivity tests. Three percent and seven percent are the discount rates generally recommended by the US Office of Management and Budget (OMB) (Congressional Research Service, 2016; Li, Q. and Pizer, W.A., 2021).

Results

A positive present value of net benefits (i.e., NPV) indicates that the project benefits exceed its costs and that the project is more efficient compared to a scenario where there is no Eco-DRR intervention. Results for Scenario 1 (Figure 7 and Table 2) show that, in the first two years since the end of the project implementation, using a 7% discount rate, the present value of net benefits (i.e., NPV) is negative and then it turns positive. After 5 years the NPV is $1,696,404.45 USD. After 10 years the NPV is positive and equal to $5,145,686.35 USD.

Estimates of the present value of net benefits (i.e., NPV) are slightly higher for Scenario 2, which also includes benefits from reforestation-induced carbon capture and sequestration and pollution reduction (Figure 8 and Table 3). After 5 years (at a 7% discount rate) - when benefits include carbon capture and pollution reduction, reduction in property damage, and income losses - the NPV is $1,722,610.02 USD. After 10 years the NPV is $5,453,427.33 USD.

It is worth emphasizing that our estimates are very conservative and benefits might be much higher than our calculations indicate. There are multiple reasons:

- The CBA assumes a 2% yearly loss in properties and GDP per capita in the project area, however historical data shows higher losses, and risk is expected to increase in relation to climate change.
- The CBA assessment considers only socio-economic benefits associated with reduced property damage and reduced GDP per capita losses. Because of lack of data we could not include other important benefits related to health improvements and agricultural productivity (discussed in Section 3.2).

This means that the interventions could be even more beneficial to local communities than estimated in the quantitative analysis. The qualitative cost-benefit assessment presented in the next section outlines the additional numerous benefits that could not be measured in monetary terms.

SCENARIO 1

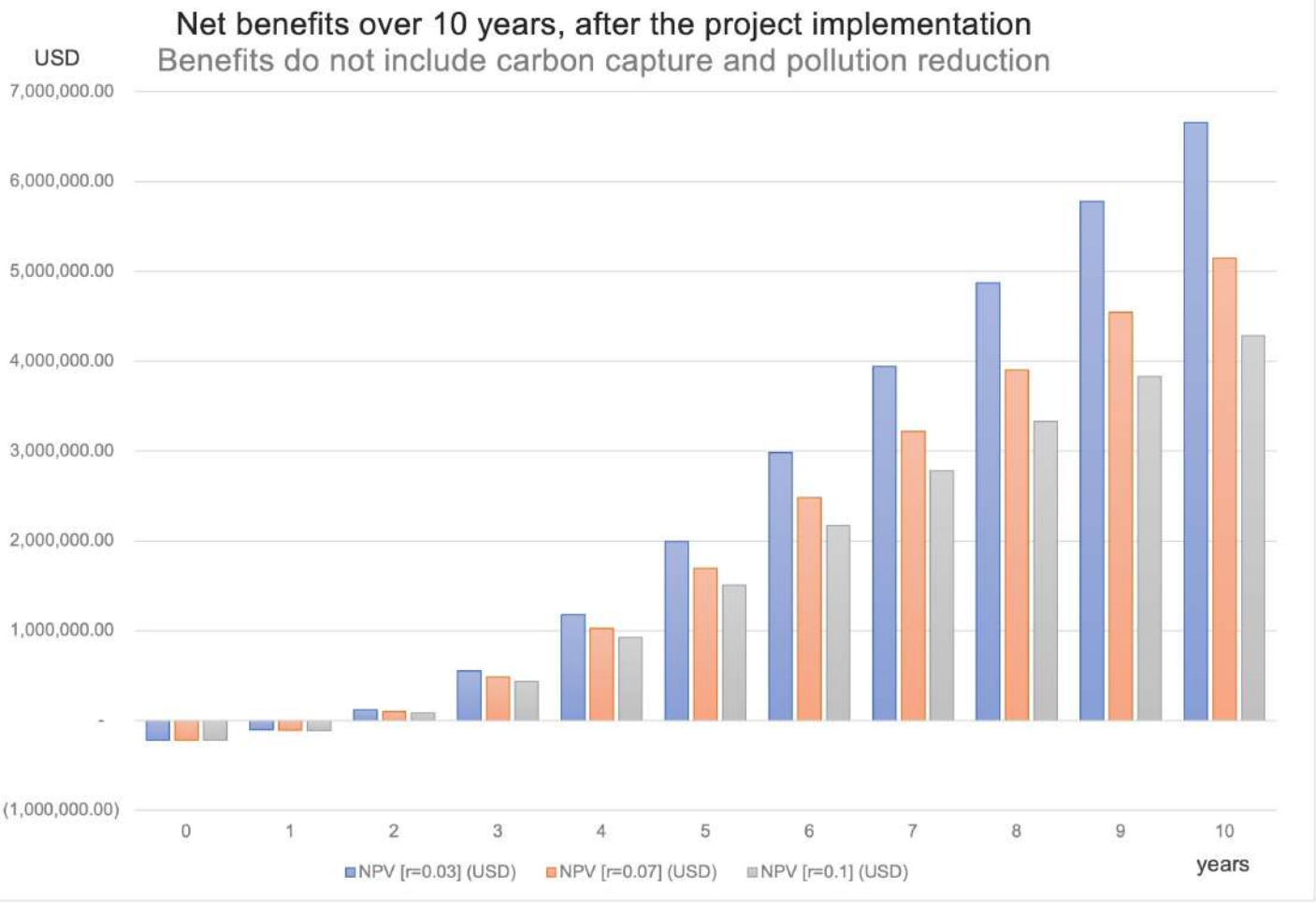


Figure 7. The graph shows the evolution of the present value of net benefits (i.e., Net Present Value, NPV) calculated over 10 years, after the project implementation, using three discount rates (i.e., 3%, 7%, and 10%). The net benefits are calculated subtracting costs from benefits. The benefits in this analysis do not include carbon capture and pollution reduction.

PRESENT VALUE OF NET BENEFITS
Benefits do not include carbon capture and pollution reduction

Discount rates	r=0.03	r=0.07	r=0.1
year	NPV (USD)	NPV (USD)	NPV (USD)
0	-$218,316.00	-$218,316.00	-$218,316.00
1	-$103,763.23	-$108,045.58	-$111,052.95
5	$1,993,798.46	$1,696,404.45	$1,508,186.05
10	$6,654,962.59	$5,145,686.35	$4,285,396.17

Table 2. The table reports the present value of net benefits (i.e., Net Present Value, NPV) calculated over 10 years, after the project implementation, using three discount rates (i.e., 3%, 7% and 10%). These NPVs were used to generate Figure 7. The benefits in this analysis do not include carbon capture and pollution reduction.

SCENARIO 2

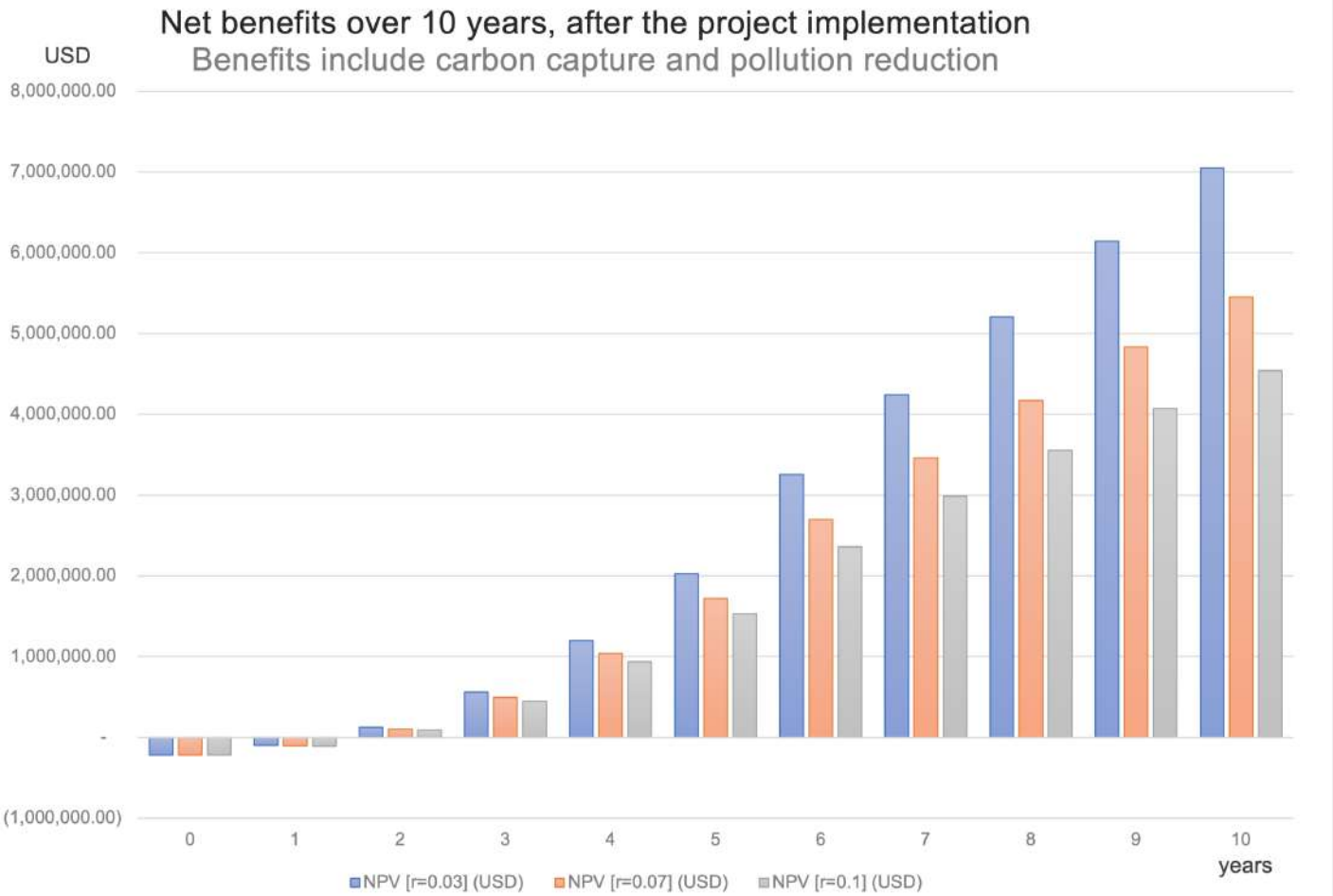


Figure 8. The graph shows the evolution of the present value of net benefits (i.e., Net Present Value, NPV) calculated over 10 years, after the project implementation, using three discount rates (i.e., 3%, 7%, and 10%). The net benefits are calculated subtracting costs from benefits. The benefits in this analysis include carbon capture and pollution reduction.

PRESENT VALUE OF NET BENEFITS
Benefits do not include carbon capture and pollution reduction

Discount rates	r=0.03	r=0.07	r=0.1
year	NPV (USD)	NPV (USD)	NPV (USD)
0	-$218,316.00	-$218,316.00	-$218,316.00
1	-$102,195.42	-$106,536.38	-$109,584.91
5	$2,024,074.27	$1,722,610.02	$1,531,815.60
10	$7,050,236.37	$5,453,427.33	$4,542,567.90

Table 3. The table reports the present value of net benefits (i.e., Net Present Value, NPV) calculated over 10 years, after the project implementation, using three discount rates (i.e., 3%, 7%, and 10%). These NPVs were used to generate Figure 8. The benefits in this analysis include carbon capture and pollution reduction.

3.2 Efficiency Assessment: Qualitative Analysis

A qualitative analysis of benefits complements our quantitative assessment. It examines all benefits identified by local partners including benefits that, while not quantifiable in monetary terms, are still essential to understanding the effectiveness of the interventions. Benefits are organized in three broad categories, consistent with the Resilience Triangle Framework: Disaster Risk Reduction (DRR), Ecosystems Management, and Sustainable Livelihood Practices. Figure 9 presents the implementation costs, the intervention benefits and their contribution to the local communities over time. For each benefit we indicate their expected duration into the future, after the project implementation, as reported by our local partners. For all benefits associated with ecosystem restoration and reforestation we assume that the local ecosystem will reach sufficient maturity to provide benefits starting after five years from the end of the project implementation. Our local partners expect that benefits will successfully extend into the future, thanks also to the capacity building and community participation components of the project.

Disaster Risk Reduction (DRR) Benefits

Benefits resulting from reforestation, hazard response preparedness, training on erosion prevention, and engineering-based infrastructure lead to reduced vulnerability to risks. In our analysis we associated them with the DRR dimension of the Resilience Triangle. They include:

Economic Benefits from Reforestation - Reforestation of over 56 ha of ecosystems is leading to a progressive increase in **soil stabilization**, which will lead to protection from flash floods, landslides and high wind events. Risk reduction is in turn creating additional socio-economic benefits. Economic benefits from lower vulnerability include **reduced property damages** and **reduced income losses** worth up to $37,220,000 USD for approximately 3,700 households, as well as GDP losses worth up to an estimated $21,775,000 USD annually. **Increased agricultural productivity** due to increased soil stability and lower risk of landslides is an additional positive externality.

Environmental Benefits from Reforestation - **Carbon sequestration** of 223 tons annually and **carbon storage** of 2,928 tons once the trees are fully matured are direct environmental outcomes of the extensive reforestation effort undertaken which includes the reforestation of 56 ha of land. Other outcomes of this intervention include **increased native biodiversity** in the reforested area, progressive **enhancement of soil characteristics** and **increase in air quality**.

Quote from a local farmer on agricultural practices leading to soil conservation and increased agricultural yield: *"Before, the technique I employed to start the beans' planting season was to burn the land / slash and burn, where normally for two marmites I planted I received 5 marmites. Now after applying the anti-erosion techniques and soil conservation with terraces retention and hurdling we can collect 3 times more, between 15 and 20 marmites. This allows us to save the seeds and replant them for the next season and develop 2 agricultural campaigns per year." -Odes Eliassaint*

Photo credit: Haiti Red Cross

Other Social Benefits from Reforestation - Significant social benefits are expected to result from reforestation activities. The conservation and protection of the 56 ha of reforested land will lead to a reduction in over 69,000 metric tons of charcoal production. This will contribute to a progressive increase in air quality, which will lead to **reduced mortality and morbidity** and **CO2 emissions reduction** of approximately 197 tons. More socio-economic benefits will derive from reforestation-induced soil stabilization, largely due to a reduction in interruptions to essential services caused by natural hazards. For example, it is expected that more reliable roads will increase access to health centers for approximately 22,333 people, leading to a **reduction in morbidity and mortality** during hazards. More reliable roads due to decreased flood risk will increase accessibility of employment centers and markets for 10,000 people, leading to **increased labor productivity**. More reliable roads due to decreased flood risk will also increase the accessibility of schools, making **education** more accessible for more than 7,000 local children. This is particularly significant for girls, for whom reliable access to school can lead to increased **gender equity** via economic empowerment.

Benefits from Soil Conservation and Erosion Prevention Training - As a result of erosion prevention training, local authorities and community members have **increased knowledge of soil conservation techniques** that reduce vulnerability due to erosion.

Benefits from Hazard Response Preparedness - As a result of community-based early warning systems and hazard response planning, local authorities and community members have **increased capacity to respond to disaster risks** and are **less vulnerable to hazards**.

Benefits from Engineering-based Infrastructure - Engineering-based green infrastructure, in combination with reforestation and soil conservation techniques, will lead to **erosion, landslide, and landfall prevention**, enhancing the ecosystem's ability to **protect against hazards and disaster risks**. **Risk reduction** and a **reduction in property damages** have been observed following the implementation of engineering-based green infrastructure in combination with reforestation efforts. For example, after the intervention, houses in the village of Dejoie did not suffer inundations following Storm Grace (2021) and the 2021 earthquake, as they had in previous years (country team communication).

Ecosystems Management Benefits

Several benefits resulting from vulnerability reduction activities and sustainable livelihoods, are associated with the Ecosystems Management dimension of the Resilience Triangle, due to their support for the proper functioning of natural ecological cycles. These benefits include:

Enhanced Ecosystem Services from Reforestation - Reforestation of more than 56 ha are leading to a progressive improvement of soil characteristics, **enhancement of soil ecosystem services** and **increase in air quality.**

Enhanced Regulating Services from Soil Conservation and Erosion Prevention Training - Training on soil conservation techniques has led to **soil stabilization and conservation**, preventing erosion and improving ecosystem regulatory services.

Enhanced Ecosystem Services from Apicultural Activities - It is expected that as a result of apicultural activities, the ecosystems surrounding apiculture sites will benefit from **protection** due to the quality of honey produced being directly affected by the quality of bee forage.

Enhanced Ecosystem Services from Sustainable Agricultural Practices - Sustainable agricultural practices including bioculture training, composting, and the planting of ten community-managed nursery sites are leading to progressive improvement in **soil health** and **soil stabilization**, further enhancing **soil-related ecosystem regulatory and provisioning services**.

Sustainable Livelihood Practices Benefits

Several activities introduced in the region as part of the community resilience intervention led to a reduction in vulnerability by improving other socio-economic indicators. These benefits are associated with the Sustainable Livelihood Practices dimension of the Resilience Triangle and they include:

Benefits from New Economic Activities - The introduction or expansion of *jaden lakou* (vegetable gardens), sustainable agricultural techniques, apicultural activities, seedling nurseries management, forest management, and forest products have created new sources of local **income and revenues**. Training in these new livelihoods is leading to **human capital accumulation** and is also **empowering women** in the community.

Benefits from Enhanced Ecosystem Services - Reforestation and the resulting **increase in provisioning services** (closer access to sustainable provision of wood and food) is facilitating **human capital accumulation**, as less time spent collecting firewood leaves more time for other income generating activities or education. Related **health improvements** derive from increased **food security** and a more diverse diet from the planting of fruit and vegetables.

Benefits from Sustainable Agricultural Practices - The introduction of sustainable agricultural and apicultural practices has contributed to an **increase in agricultural yields** as well as an **increase in the amount of honey** produced by apicultural activities. Additionally, the development of jaden lakou has contributed to **increased food security** as well as **empowering women** through a more diversified income.

Quote from a female project participant who benefited from sustainable vegetable gardens (i.e., jaden lakou): *"I produce cabbage, pepper, chili pepper and tomatoes. At the moment I am producing so much chilly pepper that after taking what we eat at home with my son, husband and me, I sell the rest at the market. I wanted to do a "good" with the money so after paying for consumption products I bought a porc"*

Jocyant, beneficiary from the locality of Sevre, Tiburon

Photo credit: Haiti Red Cross

Quote from a female project participant who benefited from sustainable vegetable gardens (i.e., jaden lakou): *"The jaden lakou has offered me a second income generated activity because I was doing commerce (petit commerce - reselling different products), now with this production when I need some money like the other day I grab some tomatoes, sell for* ***250 HTG*** *and with that I could pay the oil and salt I needed to do the household cooking. I think since I started collecting this season I have made* ***more than 3.000 HTG (around 30 USD)****"*

Josephe, beneficiary from the locality of Dussap, Chardonnières

Photo credit: Haiti Red Cross

Figure 9. This graph shows the expected duration of the benefits of the intervention, as reported by the country teams. Benefits are cataloged based on the three dimensions of the Eco-DRR Resilience Triangle (described in Section 1.2 and presented in Figure 2): Disaster Risk Reduction (DRR); Ecosystem Management, Protection and Restoration, and Climate Change Adaptation through Sustainable Livelihoods Practices.

3.3 Equity Assessment

In addition to the benefits described above, these interventions promote socio-economic equity and gender sensitivity in the target communities. This equity assessment considers the equity implications of the interventions from four perspectives: inclusivity, economic equality, participation, and capacity building.

Inclusivity

The interventions have been developed and implemented in an inclusive manner that aligned with the project's goal of capacity building. Local communities were central to the planning and implementation process, with stakeholders including women, youth, and farmers playing a key role. Staff from civil society and local government organizations including the Haitian Red Cross and Civil Protection Agency were also included as key participants due to their long standing technical and cultural expertise with the target area. Additionally, the promotion of *jaden lakou* promotes inclusivity by facilitating community involvement in land stewardship, at the individual and household level, with a particular emphasis on women. Inclusion and participation are key to promoting risk reduction, sustainable ecosystem management practices, and sustainable livelihoods.

Economic Equality

The interventions in Haiti help to fulfill basic human rights and promote economic equity by improving socio-economic outcomes for women, children, and for the communities as a whole. As a result of the disaster-risk reduction achieved through reforestation, soil stabilization, hazard preparedness planning, and engineering-based infrastructure, communities will be more resilient to natural hazards and less likely to suffer economic losses via property damage and interruptions to business, protecting beneficiaries' rights to a home and livelihood. Reduction in vulnerability to natural hazards, combined with the numerous sustainable livelihood initiatives introduced in these communities (e.g., sustainable agricultural practices and apicultural activities) will also decrease the risk of poverty traps. This includes farmers and commercial beekeepers benefiting from increased yields due to the introduction of more sustainable practices. The poorest and most marginalized individuals are likely to benefit the most from vulnerability reduction initiatives.

As a result of the reforestation and hazard prevention interventions, children's education is less likely to be interrupted by inaccessible roads preventing them from getting to school. This is particularly significant for girls whose ability to complete their education will lead to future economic empowerment and will have positive effects for generations to come. Additionally, as a result of more accessible roads people will be more reliably able to access key markets and employment centers, creating economic opportunity and promoting economic equality.

Some components of the vulnerability reduction interventions promote basic human rights to clean air and food security. As a result of the reforestation initiative (and the associated reduction in charcoal production), communities are already benefitting from cleaner air due to the increase in number of trees and reduction in CO2 emissions. Moreover, thanks to sustainable agricultural practices and *jaden lakou*, communities have already started benefitting from greater food security and access to nutritious foods. All this will lead to healthier communities and promote human capital accumulation.

An additional example of economic empowerment is associated with women's engagement in new sustainable livelihood activities and promotion of *jaden lakou*. Women in Haiti traditionally participate in markets via '*petit commerce*', selling community-produced or imported goods generally on a small scale. As a result of the interventions, women are able to sell their own vegetables, therefore increasing their access to economic markets and giving them more economic opportunity.

Participation

The participation of affected local communities is central to the interventions in Haiti. Participation of community organizations was key, with 30 local volunteers from the Haitian Red Cross being trained on disaster preparedness and response systems, and mobilized to lead community-wide awareness raising campaigns on disaster preparedness and prevention through eco-DRR.

The restoration components of the project were specifically intended to be led, implemented, and sustained by the local communities. This included local communities identifying restoration sites, growing seedlings in community nurseries, implementing soil conservation techniques, adopting agroforestry techniques in bean planting fields, and setting up natural protected zones. Community members have also agreed to restore these protected zones and preserve them from future exploitation. Additionally, individual community members were capacitated via formal training and awareness raising to participate in the Eco-DRR and sustainable livelihoods interventions. This includes participation in agricultural land restoration, erosion prevention, hazard response preparedness, and sustainable agricultural practices.

Capacity building

The interventions in Haiti focused on building the capacity of local organizations, municipal authorities, and communities to manage the disaster risks of the target area. The project leveraged existing capacities and expertise, for example of the Haitian Red Cross and Civil Protection Agency, while providing additional training and resources to increase their capacities. Moreover, the interventions have increased the capacity of local communities and local organizations through economic and environmental benefits. The transfer of knowledge perpetuated through the interventions is currently uplifting communities through sustainable economic growth, women empowerment, enhanced health and safety, and disaster risk reduction. The centrality of training and community participation to the interventions ensures that stakeholders have the necessary knowledge, skills, processes, and resources to continue these sustainable practices in the future, as well as adapt to future challenges that may arise.

3.4 Strengths and Limitations

We performed an economic efficiency assessment of the project through a quantitative Cost- Benefit Analysis and a qualitative analysis including a vast array of benefits. Our quantitative estimates show that the benefits of the Eco-DRR and resilience enhancement interventions outweigh their implementation costs. Our qualitative analysis complements these findings presenting a rich bouquet of additional long-lasting benefits (including benefits that cannot be expressed in monetary terms and therefore not incorporated in the CBA) associated with the three dimensions of the resilience triangle: DRR strategies, Ecosystem Management, and Sustainable Livelihood Practices.

We corroborated our economic efficiency assessment with an equity assessment providing a comprehensive overview of the distributional impacts of the intervention on different socio-economic groups. The large amount of qualitative data and preliminary quantitative data provided by the country teams contributes to the strength and relevance of our analyses. Despite the tight time constraints, country teams assisted the research team to the best of their abilities, often collecting new data from the field, thus laying the groundwork for possible future data collection efforts and analysis.

The analysis presented in this report is based on an approximation of the frequency and magnitude of weather hazards (i.e., hurricanes, storms, floods) in the region. More precisely, the key figure relevant for our CBA is the yearly average of the economic impact of the damages due to weather extremes. Our analyses assume a 2% yearly loss in properties and GDP per capita in the project area. This assumption is based on a conservative approximation of historical trends estimated in the existing literature (UNDDR, 2020; Centre for Research on the Epidemiology of Disasters and UNISDR, 2018) and based on the data provided by the country team. Weather extremes are expected to worsen with climate change, therefore our CBA may be underestimating the benefits of ecosystem restoration. This would make an even stronger case in support of the Eco-DRR intervention. We performed robustness checks applying a 5% yearly loss in properties and GDP per capita in the project area and found similar results available as supplementary materials. We assume that the Eco-DRR intervention will be able to reduce this risk and mitigate losses.

Ideally the CBA estimation performed in this study should consider:

1. historical frequency (i.e., probability of occurrence) and magnitude of climatic extremes (i.e., El Nino and Climate Change) that may induce floods and landslides in the project region, at least over 30 years,
2. observed correlation between intensity of extremes (e.g., floods) and damages to properties,
3. observed correlation between intensity of extremes (e.g., floods) and income losses.

Such data would allow us to better ground the value of the yearly economic damages due to climatic extremes into a robust statistical framework. Due to limited data availability the above components were not included in the analysis. Moreover, the short time available to complete the analysis did not allow us to collect primary data about these components.

Another variable that would need to be better estimated in order to increase the robustness of our CBA is the percentage of damage avoided due to the Eco-DRR intervention. Since the project is in its early stages, there is growing but not ample empirical evidence of the protective power of the nature-based solutions implemented in the project area. In our estimation we assume that, starting in year 6 after the end of the project implementation, the Eco-DRR intervention is able to completely prevent the 2% annual damages to properties and loss in GDP per capita. We adopted a conservative approach in assuming that until the 5th year after the end of the project implementation (included), while the ecosystem is maturing, there is progressive increase in benefits (i.e., 10% of benefits the first year, 20% the second year, 30% the 3rd year, 40% the 4th year and 50% the 5th year). This may lead to an underestimation of the benefits.

Our quantitative analysis lays the foundation for a possible future broader CBA of the Eco-DRR intervention in this region. Recommendations for future research, if a longer time frame for data collection and analysis is possible, include the following: collecting data related to the three components highlighted above and reproducing the CBA estimation; planning a rigorous data collection schedule in the project area to measure the observed efficacy of the local Eco-DRR interventions in limiting disaster risk. In five to ten years, the collected data could be used to perform a broad and empirically rigorous project evaluation.

4. CONCLUSION

This study contributes to the literature assessing the economic efficiency and equity of Eco-DRR activities in strengthening community resilience. We examine the project "Up-scaling Community Resilience through Ecosystem-based Disaster Risk Reduction", implemented in Haiti by the United Nations Environment Programme (UNEP) in collaboration with Partners for Resilience (PfR), a global coalition between the Netherlands Red Cross, the Red Cross/Red Crescent Climate Center, Cordaid, Wetlands International, and CARE Netherlands.

We performed an economic efficiency assessment of the project through a quantitative Cost- Benefit Analysis and a qualitative analysis that takes into account also non-monetary benefits. Our quantitative estimates show that the benefits of the Eco-DRR and resilience enhancement interventions outweigh the value of the initial costs. Our qualitative analysis complements these findings presenting a rich bouquet of long-lasting benefits associated with Eco-DRR strategies, ecosystem management, and sustainable livelihood practices.

Lastly, our equity assessment indicates that the project promotes equity by enhancing inclusivity, economic equality, participation, and capacity building. In particular, the resilience interventions implemented result in significant education, health, safety and economic improvements for women, children, and economically vulnerable members of the local communities.

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APPENDIX 1 - HAITI COSTS TABLE

INTERVENTION	DETAILS	OUTCOME 1: COMMUNITY RESILIENCE Community-Based Eco-DRR Planning	Outcome 2: ECO-DRR IMPLEMENTATION Eco-DRR Restoration and Protection Activities are Implemented	LOCATION		
				CHARDONNIERES	LES ANGLAIS	TIBURON
Response preparedness	Act 1.1 Capacity Building and skills training for HRC staff and volunteers, local authorities, CBOs (30 local HRC volunteers)	☑		☑	☑	☑
Response preparedness	Act 1.2 VCA and Commune Action Planning (four days per each area) to understand risks, exposure, resources and opportuntities	☑				
Response preparedness	Act 1.3 Set up of a mechanism of Early Warning and Early Action for planning anticipatory DRR and response preparedness action	☑		☑	☑	☑
Response preparedness	Act 1.4 Awareness Raising by using theatre, games in schools, billboards, videos, talks, radio broadcasting and (radio) contests	☑		☑	☑	☑
Reforestation	Act 2.1 Environmental Impact Monitoring in joint coordination with the Sud department branch of the Ministry of Environment		☑	☑	☑	☑
Reforestation	Act 2.2 Awareness raising and Skill training on Erosion Prevention		☑	☑	☑	☑
Reforestation	Act 2.3 Building Check dams, gabions, retaining walls and contour bunds		☑	☑	☑	☑
Reforestation	Act 2.4 Erosion Prevention through reforestation and planting of high value vegetation using Slope Agriculture Land Technology (SALT)		☑	☑	☑	☑
Reforestation	Act 2.5 Youth-led Sensitization in schools	☑		☑	☑	☑
Reforestation	Act 2.6 Apicultural activities (livelihood enhancement)	☑			☑	☑
Capacity building	Act 3.1 Enhance community-based organization capacity's by training on bio-culture including incentives to stimulate practice with their own nursery site plants, crop production and composting. (20 CBOs has reached, including local women groups and Red Cross)	☑		☑	☑	☑
Organisational development	Act 3.2 Setting up a farming field training centre (centre of excellence) in the target zone.	☑		☑	☑	☑
Food productive inputs	Act 3.3 Distribution of agricultural inputs (e.g. seeds and tools)	☑		☑	☑	☑
Total Project		**121,453 USD**	**96,863 USD**			

APPENDIX 2 - HAITI BENEFITS TABLE

RESILIENCE TRIANGLE CATEGORY	INTERVENTION DETAILS	DIRECT OUTCOME	SOCIO-ECONOMIC AND ENVIRONMENTAL BENEFITS	DETAILS	EXPECTED DURATION OF BENEFITS	LOCATION		
						CHARDONNIERES	LES ANGLAIS	TIBURON
DRR	**REFORESTATION** 56 ha degraded mountain land restored with the native tree species through the reinforcement of agroforestry and woodlot as well as the creation of natural zones.	Soil stabilization; protection from flash floods and landslides.	Economy - reduction in property damages from (avoided) landslides.	Before DRR intervention, 12 houses (valued between $10,000 USD and $30,000 USD) were inundated every year. If the land has to be taken into consideration we would need to add at least $10.000 USD. ① Haiti project team	20 years	☑	☑	☑
DRR			Economy - increased agricultural productivity.	The reduction of landslides and the solidification of the soil allows for increased viability of agriculture. ① Haiti project team	20 years	☑	☑	☑
DRR			Economy - reduction in income losses (due to business interruption).	In 2020, Haiti had a GDP per capita of $2,925 USD with a total working class of 22,333 people (estimated). ① Haiti project team	20 years	☑	☑	☑
DRR			Health - reduced morbidity (because of decreased landslides).	In 2020, Haiti had a GDP per capita of $2,925 USD with a total working class of 22,333 people (estimated). ① Haiti project team	20 years	☑	☑	☑
DRR			Health - reduced mortality (because of decreased landslides).	In 2020, Haiti had a GDP per capita of $2,925 USD with a total working class of 22,333 people (estimated). ① Haiti project team	20 years	☑	☑	☑
DRR			Education - improved accessibility to schools.	Reduced flood risk protect accessible walking routes for more than 3,000 children to get to school. ① Haiti project team	20 years	☑	☑	☑
DRR			Gender equality - more reliable access to education leads to women empowerment.	*"Women empowered through education can be leading actors, as they often form part of strong social networks within their communities and can play a vital role in the collective management of change."* ① UNESCO	20 years	☑	☑	☑
DRR			Economy - increased accessibility to markets and economic centers.	Some communities are inaccessible during rainy season because of increase river flows - walking is the primary mode of transportation when roads are flooding. ① Haiti project team	20 years	☑	☑	☑
DRR			Health - increased accessibility to healthcare centers.	Some communities are inaccessible during rainy season because of increase river flows - walking is the primary mode of transportation when roads are flooding. ① Haiti project team	20 years	☑	☑	☑
DRR		Reduced land losses.	Economy - protection of agricultural landscapes.	The reduction of landslides and the solidification of the soil allows for increased viability of agriculture. ① Haiti project team	20 years	☑	☑	☑
DRR		Carbon capture and sequestration.	Environment - carbon capture and sequestration.	56 reforested ha amount to 223.65 tons of carbon sequestered annually (valued at$18,760 USD), with a maximum carbon storage capacity of 2928.81 tons (valued at $245,392 USD). ① Benefits estimated with i-Tree	20 years	☑	☑	☑
Ecosystem Management	**REFORESTATION** 56 ha degraded mountain land restored with the native tree species through the reinforcement of agroforestry and woodlot as well as the creation of natural zones.	Increased biodiversity.	Environment - increased biodiversity.	Native biodiversity increased in protected forests and reforested areas, promoting healthy functioning of ecosystem cycles. ① Haiti project team	20 years	☑		☑
Ecosystems Management		Improved hydro-geological cycles.	Environment - improved hydro-geological cycles.	Reforestation improves hydrological or water cycle, which consists of precipitation, evaporation, evapo-transpiration, infiltration, groundwater flow and runoff. ① LEO Thesaurus, UNEP	20 years	☑	☑	☑
Ecosystems Management		Protected carbon storage.	Environment - prevention of the release of 197.34 tons of carbon.	Planting of trees in 56 ha, protecting the area from charcoal production. Through estimation, this forested area would have produced 69.015 metric tons of charcoal and, through burning, would have released 197.34 tons of CO2. ① Calculated using data from the World Bank	20 years	☑	☑	☑
Ecosystems Management		Improved air quality.	Health - reduced morbidity.	Air quality is improved through natural air cycling of forests that absorb harmful pollutant particles and emissions, preventing respiratory and cardiac disease. ① Haiti project team	20 years	☑	☑	☑
Ecosystems Management			Health - reduced mortality.	Air quality is improved through natural air cycling of forests that absorb harmful pollutant particles and emissions, preventing death related to respiratory and cardiac disease. ① Haiti project team	20 years	☑	☑	☑
Ecosystems Management		Prevented charcoal production.	Health - reduced morbidity.	Prevention of charcoal production and subsequent burning limits harmful pollutant particles and emissions from entering local communities, preventing respiratory and cardiac disease. ① Haiti project team	20 years	☑	☑	☑
Ecosystems Management			Health - reduced mortality.	Prevention of charcoal production and subsequent burning limits harmful pollutant particles and emissions from entering local communities, preventing death related to respiratory and cardiac disease. ① Haiti project team	20 years	☑	☑	☑
Ecosystems Management	**TREE NURSERIES** 10 community-based seedlings nurseries managed by communities. (Each has a capacity of 3,000 to 10,000 seedlings).	Improved air quality.	Health - reduced morbidity.	Air quality is improved through natural air cycling of forests that absorb harmful pollutant particles and emissions, preventing respiratory and cardiac disease. ① Haiti project team	10 years	☑	☑	☑
Ecosystems Management			Health - reduced mortality.	Air quality is improved through natural air cycling of forests that absorb harmful pollutant particles and emissions, preventing respiratory and cardiac disease. ① Haiti project team				
Ecosystems Management	**TRAINING ON EROSION PREVENTION** Implementing soil conservation techniques.	Soil stabilization and conservation.	Environment - soil preservation.	Prevention of erosion supports flood management and increased agricultural productivity. ① Haiti project team	10 years	☑	☑	☑

APPENDIX 2 - HAITI BENEFITS TABLE - continued -

RESILIENCE TRIANGLE CATEGORY	INTERVENTION DETAILS	DIRECT OUTCOME	SOCIO-ECONOMIC AND ENVIRONMENTAL BENEFITS	DETAILS	EXPECTED DURATION OF BENEFITS	LOCATION		
						CHARDONNIERES	LES ANGLAIS	TIBURON
Sustainable Livelihoods	**REFORESTATION** Adopting agroforestry techniques.	Revenues from new agroforestry products.	Economy - revenue from new agroforestry products.	*"I produce cabbage, pepper, chili pepper and tomatoes. At the moment I am producing so much chilly pepper that after taking what we eat at home my son, husband and me, I sell the rest at the market. I wanted to do a "good"with the money so after paying for consumption products I bought a porc."* ① Haiti project team, quote from Jocyant (beneficiary from Sevre, Tiburon)	30 years	☑	☑	☑
Sustainable Livelihoods	**SUSTAINABLE AGRICULTURE** Planting of bean fields and setting up natural protected zones which will be formalized by the community by-laws.	Increased food security because of planting of bean fields.	Health - increased food security.	*"I produce cabbage, pepper, chili pepper and tomatoes. At the moment I am producing so much chilly pepper that after taking what we eat at home my son, husband and me, I sell the rest at the market. I wanted to do a "good"with the money so after paying for consumption products I bought a porc."* ① Haiti project team, quote from Jocyant (beneficiary from Sevre, Tiburon)	20 years	☑	☑	☑
Sustainable Livelihoods		Revenues from improved agricultural production.	Economy - revenue from improved agricultural production.	*"Before the technique I employed to start the beans planting season it was to burn the land or slash and burn, where normally for two marmites I planted I received 5 marmites. Now after applying the anti erosion techniques and soil conservation with terraces retention and hurdling, we can collect 3 times more, between 15 and 20 marmites. This allows us to save the seeds and replant them for the next season and develop 2 agricultural campaigns per year."* ① Haiti project team, quote from Odes Eliassaint	20 years	☑	☑	☑
Sustainable Livelihoods	**TREE NURSERIES** 10 community-based seedlings nurseries managed by communities. (Each has a capacity of 3,000 to 10,000 seedlings).	Wages and revenues from agricultural livelihoods activities.	Economy - wages.	Supports existing agricultural livelihoods through greater distribution of revenue.	10 years	☑	☑	☑
Sustainable Livelihoods			Economy - revenues.	An assessment of local markets showed the low diversity of sold products, as most of the farmers only focus on the production of different variety of beans, corn and banana - which are sold at daily market prices to wholesalers coming from the nearest city. Increased production of fruit through operational tree nurseries help to diversity available food and improve food security. The surplus can be sold in the local market to raise additional household income. ① Haiti project team	10 years	☑	☑	☑
Sustainable Livelihoods	**APICULTURAL ACTIVITIES** Training of beekeeping and hive maintenance.	Wages and revenues from bee products.	Economy - wages.	The jobs related to this market is apicultures, cooperatives which gathered product, local market sellers, supermarkets. ① Haiti project team	30 years		☑	☑
Sustainable Livelihoods			Economy - revenues.	Every gallon of honey has a market value 5,000 HTG ($48 USD). The increase from traditional to modern techniques is multiplied by two times. For example, using prior methods the farmers were making around 2 gallons a year (10,000 HTG or $98 USD). Now they can produce 4 gallons a year (20,000 HTG or $196 USD). ① Haiti project team	30 years		☑	☑
Sustainable Livelihoods	**JARDEN LAKOU (i.e., VEGETABLE GARDENS)** 8 community women groups trained and engaged in vegetable gardening for livelihood strengthening.	Women empowerment.	Gender equality - training is a form of "human capital accumulation" that may lead to women empowerment.	*"I produce cabbage, pepper, chili pepper and tomatoes. At the moment I am producing so much chilly pepper that after taking what we eat at home my son, husband and me, I sell the rest at the market. I wanted to do a "good"with the money so after paying for consumption products I bought a porc."* ① Haiti project team, quote from Jocyant (beneficiary from Sevre, Tiburon)	15 years	☑	☑	☑
Sustainable Livelihoods		Improved access to markets.	Economy - training may lead to more opportunities for work and increased wages.	Women traditional activity in Haiti is petit commerce "local market sellers"of community or imported products in low scale. The production of vegetables allows them to have easier access to these activities and to sale their own production. ① Haiti project team	15 years	☑	☑	
Sustainable Livelihoods		Revenues from garden projects and food security for the family.	Economy - revenue from garden projects.	The term "jarden lakou"is the traditional set up of having an horticultural garden or cereal at every house, which is used for the consumption and extra revenu for sale. These gardens are constantly used by traditional system of rotation with different cultures: cereals, bananas, horticulture, tubercules and newly agroforestry / medicinal trees; also mostly happen within the households. *"The jaden lakou has offered me a second IGA because I was doing commerce (petit commerce - reselling different products), now with this production when I need some money. The other day I grabbed some tomatoes, sold them for 250 HTG and with that I could pay for the oil and salt I needed to do the household cooking. I think since I started collecting this season, I have made more than 3.000 HTG (around 30 USD)."* ① Haiti project team, quote from Josephe (beneficiary from Dussap, Chardonnieres)	15 years	☑	☑	☑
Sustainable Livelihoods			Economy - food security for the family.	*"I produce cabbage, pepper, chili pepper and tomatoes. At the moment I am producing so much chilly pepper that after taking what we eat at home my son, husband and me, I sell the rest at the market. I wanted to do a "good"with the money so after paying for consumption products I bought a porc."* ① Haiti project team, quote from Jocyant (beneficiary from Sevre, Tiburon)	15 years	☑	☑	☑
Sustainable Livelihoods		Strengthened cultural heritage.	Culture - strengthening of cultural heritage.	Cultural heritage is in the way it continues with a household and family approach, the historic land problem troubles in Haiti given to a few hands or the states, makes the care about the land for individuals much harder. It has brought overexplotation of the mountain lands and charcoal extraxtion. This phenomenon it is not seen at jarden lakous. 1st because they need the shadow to live, as well as the crops. No problems on land issues to lose the household production in hand of someone that claims it	15 years	☑	☑	☑

APPENDIX 2 - HAITI BENEFITS TABLE - continued -

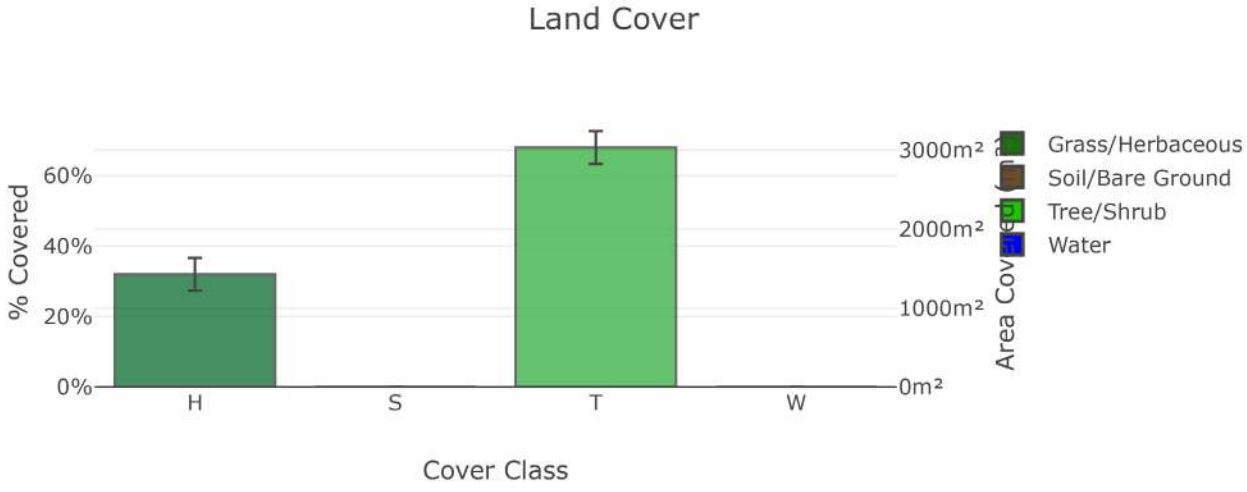
RESILIENCE TRIANGLE CATEGORY	INTERVENTION DETAILS	DIRECT OUTCOME	SOCIO-ECONOMIC AND ENVIRONMENTAL BENEFITS	DETAILS	EXPECTED DURATION OF BENEFITS	LOCATION		
						CHARDONNIERES	LES ANGLAIS	TIBURON
Sustainable Livelihoods	**REFORESTATION** 56 ha degraded mountain land restored with the native tree species through the reinforcement of agroforestry and woodlot as well as the creation of natural zones/	Revenues from forest products and agroforestry activities.	Economy - revenue from forest products.	Some market products can be collected without cutting down the tree. ① Haiti project team	20 years	☑	☑	☑
Sustainable Livelihoods			Economy - added economic activities (income generating-activities).	Technical activities have allowed some farmers to double the quantity of harvested black beans on their agriculture plots. This means a portion of the harvest can be kept for next season's replanting. ① Haiti project team	20 years	☑	☑	☑
Sustainable Livelihoods		Reduced mortality and morbidity.	Health - reduced morbidity (because of increased revenues or nutrition from new tree fruits).	*"Adequate consumption of fruit and vegetables reduces the risk for cardiovascular diseases, stomach cancer and colorectal cancer."* ① World Health Organization (WHO)	20 years	☑	☑	☑
Sustainable Livelihoods			Health - reduced mortality (because of increased revenues or nutrition from new tree fruits).	*"Approximately 16 million (1.0%) DALYs and 1.7 million (2.8%) of deaths worldwide are attributable to low fruit and vegetable consumption."* ① World Health Organization (WHO)	20 years	☑	☑	☑

APPENDIX 3 Carbon capture and pollution reduction calculations using the software Itree

i-Tree Canopy v7.1

Cover Assessment and Tree Benefits Report

Estimated using random sampling statistics on 3/27/2022



APPENDIX 3 ITree Calculations - continued -

Abbr.	Cover Class	Description	Points	% Cover ± SE	Area (m^2) ± SE
H	Grass/Herbaceous		32	32.00 ± 4.66	1427.19 ± 208.05
S	Soil/Bare Ground		0	0.00 ± 0.00	0.00 ± 0.00
T	Tree/Shrub		68	68.00 ± 4.66	3032.77 ± 208.05
W	Water		0	0.00 ± 0.00	0.00 ± 0.00
Total			**100**	**100.00**	**4459.96**

Tree Benefit Estimates: Carbon (Metric units)

Description	Carbon (t)	±SE	CO_2 Equiv. (t)	±SE	Value (USD)	±SE
Sequestered annually in trees	1.78	±0.12	6.53	±0.45	$335	±23
Stored in trees (Note: this benefit is not an annual rate)	23.31	±1.60	85.46	±5.86	$4,382	±301

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Amount sequestered is based on 0.001 t of Carbon, or 0.002 t of CO_2, per m^2/yr and rounded. Amount stored is based on 0.008 t of Carbon, or 0.028 t of CO_2, per m^2 and rounded. Value (USD) is based on $188.00/t of Carbon, or $51.27/t of CO_2 and rounded. (Metric units: t = tonnes, metric tons, m^2 = square meters)

Tree Benefit Estimates: Air Pollution (Metric units)

Abbr.	Description	Amount (kg)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	1.12	±0.08	$2	±0
NO2	Nitrogen Dioxide removed annually	6.02	±0.41	$1	±0
O3	Ozone removed annually	11.26	±0.77	$11	±1
SO2	Sulfur Dioxide removed annually	1.12	±0.08	$0	±0
PM2.5	Particulate Matter less than 2.5 microns removed annually	1.79	±0.12	$58	±4
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	14.01	±0.96	$100	±7
Total		**35.31**	**±2.42**	**$172**	**±12**

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Air Pollution Estimates are based on these values in kg/m^2/yr @ $/kg/yr and rounded:
CO 0.000 @ $1.52 | NO2 0.002 @ $0.15 | O3 0.004 @ $0.97 | SO2 0.000 @ $0.07 | PM2.5 0.001 @ $32.22 | PM10* 0.005 @ $7.15 (Metric units: kg = kilograms, m^2 = square meters)

Tree Benefit Estimates: Hydrological (Metric units)

Abbr.	Benefit	Amount (l)	±SE	Value (USD)	±SE
AVRO	Avoided Runoff	133.78	±9.18	$0	±0
E	Evaporation	6,227.87	±427.23	N/A	N/A
I	Interception	6,262.58	±429.61	N/A	N/A
T	Transpiration	8,252.55	±566.12	N/A	N/A
PE	Potential Evaporation	27,540.56	±1,889.27	N/A	N/A
PET	Potential Evapotranspiration	24,942.90	±1,711.07	N/A	N/A

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Hydrological Estimates are based on these values in l/m^2/yr @ $/l/yr and rounded:
AVRO 0.044 @ $0.00 | E 2.054 @ N/A | I 2.065 @ N/A | T 2.721 @ N/A | PE 9.081 @ N/A | PET 8.224 @ N/A (Metric units: l = liters, m^2 = square meters)

About i-Tree Canopy

The concept and prototype of this program were developed by David J. Nowak, Jeffery T. Walton, and Eric J. Greenfield (USDA Forest Service). The current version of this program was developed and adapted to i-Tree by David Ellingsworth, Mike Binkley, and Scott Maco (The Davey Tree Expert Company)

Limitations of i-Tree Canopy

The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be too high to have any real certainty of the estimate.

Additional support provided by:

Use of this tool indicates acceptance of the EULA.