Ex Ante Cost Benefit Analyses of Community-Based DRR Interventions in the Caribbean

Meenakshi Jerath  
*Florida International University, mjerath@fiu.edu*

Juan Pablo Sarmiento  
*Florida International University, juan-pablo.sarmiento@fiu.edu*

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Authors:

Meenakshi Jerath and Juan Pablo Sarmiento

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About the Authors

Meenakshi Jerath is the Coordinator of Research Programs at the Disaster Risk Reduction (DRR) Program at the Extreme Events Institute in Florida International University (FIU) in Miami, Florida. She specializes in cost benefit analysis (CBA) of DRR interventions and in environment resource management. She is the course coordinator for a graduate level course on CBA in DRR offered by the DRR Program at FIU for which she designs CBA applications. She has conducted face-to-face and online training workshops in CBA for project managers from external organizations. She also teaches Ecology of South Florida as an adjunct faculty of FIU.

Meenakshi obtained her Master of Science in Environmental Studies from FIU with specialization in Environmental Economics, Environmental Policy, Resource Management and Geographic Information Systems. Her master’s thesis focused on the quantification and valuation of carbon storage by the mangrove forests in Everglades National Park, Florida. She has presented her research work at the International Conference of the International Society of Ecological Economics at Rio de Janeiro in June 2012. She has a M.Sc. and B.Sc. in Zoology, and a Bachelor’s in Science Education from the University of Delhi, India.

Dr. Juan Pablo Sarmiento is a Research Professor at the Department of Health Policy and Management in the Robert Stempel College of Public Health and Social Work, Florida International University (FIU). He is also the Director of the Disaster Risk Reduction Program, funded by the U. S. Agency for International Development and housed in the FIU Extreme Events Institute. Dr. Sarmiento is a Medical Doctor and Surgeon (Universidad del Rosario, Colombia, 1981) with M.A. degrees in Medical Education (Universidad de la Sabana, Colombia, 1998), and Project Management (UCI, Costa Rica, 2004). He has also post-graduate studies in Disaster Management (Oxford, Great Britain, 1989); High Level Public Administration (Colombian Superior School of Public Administration, 1996), a residence in Nutrition (Tufts University, U.S.A., 1998), and a certificate in Health Promotion (Bordeaux, France, 2014). He has three decades of professional experience in health, health education, and risk and disaster management at the national (Colombia), international (World Health Organization) and U.S. Government (Office of U.S. Foreign Disaster Assistance) levels, with extensive health crisis and field experience, including disaster response in Latin America and the Caribbean.
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his report presents a study on the cost benefit analyses (CBA) and cost effectiveness analysis (CEA) of community-based disaster risk reduction (DRR) interventions in the Caribbean. The DRR interventions, implemented by the International Federation of Red Cross (IFRC), Port of Spain, in three Caribbean countries, Jamaica, Antigua & Barbuda, and Suriname, comprised the pilot phase of the Red Cross (RC) Project, Improving Climate Change Resilience of Caribbean Communities. This study is part of the endeavor by the DRR Program of Florida International University (FIU) and the United States Agency for International Development’s Office of the U.S. Foreign Disaster Assistance (USAID/OFDA) to develop and foster DRR measures in the Latin American and Caribbean region since 2008. Florida International University’s DRR Program began its efforts in addressing the need for CBA in DRR at two levels:

1. Development of a graduate level academic course on CBA in DRR with a trial hands-on workshop in 2012 and the delivery of the online course in 2013.


The purpose of this study was to use economic tools such as cost benefit analysis (CBA) and cost effectiveness analysis (CEA) to estimate the potential net benefits arising from five community-based DRR interventions implemented in 13 Caribbean communities. The cost benefit analysis of the proposed micro-projects was an important prerequisite of the funding process by United Kingdom’s Department for International Fund (DFID).
This report comprises a prologue and six chapters.

Chapter 1 provides an introduction to disaster risk and climate change in the Caribbean context.

Chapter 2 provides an overview of the pilot phase of the Red Cross Project, “Improving Climate Change Resilience of Caribbean Communities” as implemented by the IFRC, and of the present study by the FIU-DRR Program on the ex ante CBA of community-based DRR interventions.

Chapter 3 describes the general methodology of cost benefit and cost effectiveness analysis used by the FIU-DRR Program to analyze the community-based interventions in the pilot phase of the Red Cross project.

Chapter 4 presents five case studies on the economic analyses of the DRR interventions in 13 communities in Jamaica, Antigua & Barbuda, and Suriname.

1) CBA of the Safer Shelters Component of the Red Cross Project in five communities in Jamaica.

2) CBA of the Diamond Hole Dam Restoration Micro-project in Bendals community in Antigua & Barbuda.

3) CEA of the Vector Control Micro-project in the communities of Yorks and Piggotts in Antigua & Barbuda.


5) CBA of the Greenhouse Farming Micro-project in Coronie, Suriname

Each case study, in general, follows the methodology given in Chapter 3. A brief introduction is followed by the details of the proposed intervention and of the CBA or CEA methodology implemented, and ends with recommendations based on the results of the economic analysis.

Chapter 5 presents the key findings and a discussion of the results of the economic analysis.

Chapter 6 provides brief conclusions and recommendations for further action.
Chapter 1: Introduction

This study presents FIU-DRR Program’s economic analysis of the pilot phase of the Red Cross (RC) Project, *Improving Climate Change Resilience of Caribbean Communities*. The Red Cross project in its pilot phase included a series of community-based disaster risk reduction (DRR) interventions implemented by the IFRC in 13 communities\(^1\) of three Caribbean countries, Jamaica, Antigua & Barbuda, and Suriname. The objective of this study was to estimate the potential net benefits arising from the proposed DRR interventions in these Caribbean communities through economic tools such as CBA and CEA.

**DISASTER RISK, CLIMATE CHANGE, AND THE CARIBBEAN**

Natural disasters like hurricanes, flooding, landslides, and droughts frequently affect the 40 million vulnerable residents of the two dozen island nations in the Caribbean region (Bueno et al. 2008; [http://www.caribbeanclimate.bz/](http://www.caribbeanclimate.bz/)). These islands are especially vulnerable to the predicted impacts of global climate change, sea level rise (SLR), and extreme events because of their remoteness, low elevation, small land masses, and heavy concentration of populations and infrastructure in the coastal areas (IPCC, 2007; Simpson et al., 2010). Climate change, driven by natural variability and persistent anthropogenic changes, is projected to lead to changes in the frequency, intensity, spatial extent or duration of weather and climate extremes such as tropical cyclones, heavy precipitation events, droughts, and heat waves (IPCC, 2012). Rising sea levels and related impacts such as inundation, erosion, change in

\(^1\) In this project the Red Cross uses the term ‘communities’ interchangeably with ‘villages’. Communities are identified as self-contained groups of houses, the size of a village, with a characteristic village life. The communities referred to in Suriname are actually districts containing several small communities within.
Chapter 1: Introduction

Shorelines, and the intrusion of saltwater into coastal freshwater aquifers will directly affect the low lying Caribbean islands (IPCC, 2012).

The IPCC in its 2001 report stated that the impacts of climate change will be distributed non-uniformly with developing countries having to bear the brunt of responsibility for climate change mitigation and adaptation. This is likely to exacerbate the negative impacts on the economic and social development of the small island developing states (SIDS) of the Caribbean already riddled with frequent setbacks from natural disasters. Insufficient resources, the lack of robust and diverse economies, and limited technical and institutional capacity limit the ability of the Caribbean nations to build resilience towards impending climate change impacts (Bueno et al., 2008; Simpson et al., 2010). According to an assessment of economic impacts of natural disasters between 1970 and 1997, the GDP growth of Caribbean countries tended to slow down during the year of the event by 3.1% on an average (Caribbean Development Bank report, Croward, 2000). In addition to such negative impacts on the economy, the SIDS must now take into account the potential annual costs of global climate inaction if climate change impacts are not mitigated. The potential costs of global climate inaction for the Caribbean countries are estimated to increase from 5% in 2025 to 10% in 2050, and to 22% by 2100 compared to the 2004 GDP (Bueno et al., 2008).

The impacts of climate change constitute an environmental problem that is global in origin and scale; the problem has attracted the concerns of social actors at all levels of society. The growing consensus indicates that significant solutions lie in reducing the social, economic, and environmental vulnerability of the Caribbean populations by building the resilience at the community level. The traditional response to disasters in the form of post-disaster relief and aid has undergone a gradual shift to a more anticipatory, forward-looking, and comprehensive approach of disaster preparedness and disaster risk reduction. The disaster risk reduction approach focuses on the analysis of risk, reduction of vulnerabilities, and building of resilience in the affected community, thus providing a relevant context to address climate change impacts (Thomalla et al., 2006; Venton and Venton, 2004).

In recent years, the appraisal of DRR projects using tools of economic analysis such as cost benefit analysis has gained traction among the international DRR community. Cost benefit analysis (CBA) is an economic tool that has been regularly employed in the evaluation process for development projects by development banks such as the World Bank, Asian Development Bank, and the Inter-American Development Bank, and by countries like the United States and the United Kingdom (Mechler, 2008). Cost benefit analysis is increasingly seen as a requirement to complete the project cycle by donor agencies and non-governmental organizations (NGOs) that implement DRR projects. Economic analyses of DRR projects,
in the form of cost benefit or cost effectiveness analysis, help in eliminating risky projects by identification of suitable interventions among project alternatives. They provide research-based evidence to verify the return of investment on each project and help in making informed decisions (Venton and Venton, 2004).

**RED CROSS, CLIMATE CHANGE, AND DRR**

The Caribbean nations have taken several steps since 2008 to bolster disaster risk reduction services to vulnerable communities. The Community Based Disaster Management (CBDM) program has added standardized community disaster response team training and resourcing, funded mitigation plans of action and risk reduction projects, and Community-Based Health and First Aid (CBHFA). The CBDM program implemented in 16 countries has directly benefitted over 200,000 people in 168 communities, mostly women and girls (IFRC Proposal, 2011). Additionally, over 1 million people have been served directly and indirectly by the Red Cross epidemic and outbreak programs (HIV AIDS, AH1N1, dengue fever) implemented in 2010 (IFRC Proposal, 2011). These initiatives have fostered first response capabilities of communities which in turn has the potential of reducing the risk to hazards such as flooding, bush fires, and disease vectors (IFRC Proposal, 2011).

**THE RED CROSS PROJECT: IMPROVING CLIMATE CHANGE RESILIENCE OF CARIBBEAN COMMUNITIES**

The Red Cross Project, Improving Climate Change Resilience of Caribbean Communities, is part of the Red Cross regional integrated climate change and DRR strategic framework with the goal to deliver reduced disaster and climate change impact in the Caribbean. The project aims to achieve the aforesaid goal by increasing the resilience of vulnerable communities and strengthening the main resilience factors such as homes, health, livelihoods, community environment and connections through greater knowledge, preparedness, skill, and CC adaptation applications. For the pilot phase of the IFRC project, three Caribbean island nations: Jamaica, Antigua & Barbuda, and Suriname were selected for their higher climate change risk, larger capacity for resources, and for being representative of the region. The primary goal of the pilot phase was that vulnerable communities in the Caribbean become more resilient to climate change and natural disasters. The objective of the pilot phase was to achieve three specific results: (1) Output 1: Community homes are safer against disaster and climate change hazards; (2) Output 2: At least 13 communities implement risk reduction projects and readiness actions; and (3) Output 3: Knowledgeable communities take action to reduce health risk.
PURPOSE OF THE STUDY

The purpose of this study by FIU’s DRR Program was to perform economic analyses of the proposed community-based DRR interventions in the 13 communities of the Caribbean. The analyses of the DRR interventions estimated the costs incurred by the society and the benefits accrued to the community in general.
OBJECTIVES OF THE RED CROSS PROJECT

The primary goal of the Red Cross Project, *Improving Climate Change Resilience of Caribbean Communities*, was to increase the resilience of vulnerable Caribbean communities against the impacts of climate change and natural disasters. The aim of the pilot phase of the Red Cross project was to accomplish the abovementioned goal by pursuing three objectives:

1. **Output 1:** Community homes are safer against disaster and climate change hazards.

   By their actions, community members demonstrate and train neighbors to apply recommended home retrofitting as well as flood-prevention applications (100 homes) in 13 communities in Suriname, Jamaica, and Antigua & Barbuda. The Red Cross will pilot the application of strengthening walls and roofs to a minimum 50 homes in Jamaica, advocate with the national authorities and other partners for similar shelter strengthening for the vulnerable and for the adoption of construction best practice and codes, where these do not exist. Where relevant, communities will also implement with national authorities, low cost early warning systems to floods.

2. **Output 2:** At least 13 communities implement risk reduction projects and readiness actions. This includes education and awareness of climate change. It will require using the vulnerability and capacity assessment (VCA) reports developed by the community to identify risk reduction (RR) projects e.g., improved drainage, slope and
livelihood protection, RR equipment, etc., that reduce the shocks and stresses of hydro-meteorological disasters. Community disaster response team (CDRT) refresher training for 22 communities will be rolled out. These teams will then be available to provide first response during emergencies.

3. Output 3: Knowledgeable communities take action to reduce health risk. The refreshed CDRT and other community volunteers will also be trained to provide health awareness and peer education for their neighbors to prevent the proliferation of disease vectors and the spread of disease. Where necessary, small health improvement projects will be implemented.

IMPLEMENTATION OF THE PILOT PHASE OF THE RED CROSS PROJECT

The pilot phase of the Red Cross Project was implemented by the IFRC in the period between March 2012 and March 2014 (See Timeline of Events, Table 1). It is important to note that Output 1, implemented in Jamaica as the Safer Shelters Component of the Red Cross Project, was a large-scale intervention and does not fall into the category of a ‘micro-project’ as do all the other interventions that were implemented in Antigua & Barbuda and in Suriname (as part of Outputs 2 and 3). Consequently, the implementation process of the Safer Shelters Component differed from that of the micro-projects (Figure 1).
Table 1: Overview of the Timeline of Events of the Red Cross (RC) Project and FIU-DRR Program’s CBA of the community-based DRR interventions

<table>
<thead>
<tr>
<th>Date</th>
<th>Timeline Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 2012</td>
<td>Tripartite agreement for the RC Project between DFID, IFRC, British Red Cross</td>
</tr>
<tr>
<td>July 2012</td>
<td>Selection of countries, MoUs with Antigua and Barbuda, Jamaica and Suriname Red Cross National Societies</td>
</tr>
<tr>
<td>September - October 2012</td>
<td>Selection of communities based on Community Selection Tool; IFRC Project Manager takes over the pilot phase of the RC Project</td>
</tr>
<tr>
<td>October 2012</td>
<td>Hurricane Sandy impacts Jamaica</td>
</tr>
<tr>
<td>October 2012 - February 2013</td>
<td>Baseline Surveys: KAP, JHU tools - Training and conduction of surveys</td>
</tr>
<tr>
<td>October 2012</td>
<td>Discussion begin for hiring CBA expertise</td>
</tr>
<tr>
<td>November 2012 to April 2013</td>
<td>Vulnerability and Capacity Assessments (VCAs)</td>
</tr>
<tr>
<td>December 2012 - March 2013</td>
<td>Training on CCCA toolkit, integration of CCCA with VCAs</td>
</tr>
<tr>
<td>January 2013</td>
<td>National Training on Safehouse Methodology, Jamaica; Implementation of DRR interventions begin with Output 1-Safer Shelters; Institutional agreement between IFRC and FIU</td>
</tr>
<tr>
<td>April 2013</td>
<td>Field visits to communities in Jamaica, Antigua &amp; Barbuda by FIU-DRR Program CBA analyst</td>
</tr>
<tr>
<td>June 2013</td>
<td>FIU-DRR Program conducts training on CBA and CEA methodology and implementation for RC National Society project managers and field officers</td>
</tr>
<tr>
<td>July 2013 - August 2013</td>
<td>FIU-DRR Program implements CBA methodology for DRR interventions in Jamaica, and Antigua &amp; Barbuda</td>
</tr>
<tr>
<td>July 2013 - October 2013</td>
<td>FIU-DRR Program implements CBA methodology for Suriname DRR micro-projects</td>
</tr>
<tr>
<td>March 2014</td>
<td>Implementation of all DRR interventions are completed</td>
</tr>
<tr>
<td>March 2014</td>
<td>Endline Surveys</td>
</tr>
</tbody>
</table>
Selection of Countries

The IFRC-Caribbean Regional Representational Office (CRRO) team selected Suriname, Jamaica, and Antigua & Barbuda for the pilot phase primarily for being best representative of the continental territories and the SIDS of the Caribbean region. Secondly, the countries face similar risks from climate change and sea level rise; 50 – 90% of the population and 20 – 60% of the tourism and industrial facilities in these countries are located on the coastline (Bueno et al. 2008).

The Caribbean Development Bank identified Antigua & Barbuda as one of the countries most affected by natural disasters from 1950 to 1998. Besides strengthening hurricanes, the risk from sea level rise in the country will mostly occur in the form of localized impacts from erosion, flooding and inundation, and salt water intrusion of ground water (CARIBSAVE, 2012).

Sixty percent of Jamaica’s population is located in at-risk coastal communities that are vulnerable to storm surges, hurricanes, and flooding (CARIBSAVE, 2012). 16% of the population has been affected by weather related disasters (floods, droughts and hurricanes)
with 50 deaths reported in the period of 2000 – 2009 (EM-DAT database). Poverty exacerbates the vulnerability of these populations, 16% of which are below poverty line (CIA Fact book estimate, 2009).

Climate change related events like changes in temperature and rainfall are affecting crop production, river quality, and freshwater availability in Suriname. Flooding and drought events have led to losses in livelihood and affected food security (CARIBSAVE, 2012). Agriculture contributes significantly to Suriname’s GDP with 96% of land under rice production. However, the production is concentrated in the coastal region where the effects of climate change and sea level rise are increasingly evident (CARIBSAVE, 2012). Farmers have noted the gradual decrease in productivity of previously fertile lands as a result of increased salt water intrusion (personal communication with Project Manager, Suriname Red Cross). Community members face increased health risks from poor water quality issues and the proliferation of mosquitoes (CARIBSAVE, 2012).

Lastly, the three countries had the best capabilities in terms of project implementation at the time of selection. Each of the chosen Red Cross National Societies had proven effective in delivering community risk assessments by actively engaging with communities and collaborating with national partners.

The IFRC signed the Memoranda of Understanding (MoU) with the Red Cross National Societies (NS) of Antigua & Barbuda, Jamaica and Suriname for implementation of DRR interventions in July 2012 (Table 1).

Selection of Communities

A survey-based Community Selection Tool (CST) developed by the Resource Center in Jamaica was used to select vulnerable communities in which DRR interventions would be implemented. The plan was to include those communities where the Red Cross had previously worked and where VCAs had already been conducted. This would save on time and resources and assist in establishing the baseline for disaster risk in each community. However, only Antigua and Barbuda was able to work in familiar communities while Jamaica and Suriname chose new communities to implement the micro-projects for which fresh VCAs had to be conducted.

It is important to note that the term ‘community’ used the by Red Cross is one that is interchangeable with the term ‘village’. The Red Cross loosely identifies communities as self-contained groups of houses, the size of a village, with a characteristic village life. Five communities, Windsor, Prospect, Flint River, Gully Road, and Killancholly were selected in Jamaica. In Antigua & Barbuda, three communities, Bendals, Yorks, and Piggotts were selected. In Suriname, the identified communities were extremely small in size. As a result,
districts were selected (Coronie, Coppename, Commewijne, and Saramacca), each with several small communities within them. Henceforth, this document will continue to refer to the districts in Suriname as communities.

**Baseline Surveys**

To establish the baseline scenario on disaster risk and vulnerabilities of communities, and to identify suitable interventions in each community under Outputs 2 and 3, the IFRC began the process of micro-project implementation using the results of surveys described below. Youth volunteers were first trained in conducting the surveys.

1. Knowledge-Awareness-Perspective or KAP Surveys were implemented in the selected communities by trained volunteers. The baseline surveys assessed the knowledge, attitudes, and practices/behavior of community members with respect to climate change and health risks. The two kinds of surveys used were:
   a. The JHU Tool to measure community resilience through household and focus group surveys. In Antigua & Barbuda and Suriname only household surveys were conducted. Jamaica used both household and focus group surveys.
   b. The CBHFA (health) Survey to specifically measure health risk perception among community members.

2. The Vulnerability and Capacity Assessment (VCA) is a participatory investigative process designed to assess the risks faced by community members in their locality, their vulnerability to those risks, and the capacities they possess to cope with a hazard and recover from it when it strikes. The initial plan by the IFRC was to use the results of previously conducted VCAs to gather information on the vulnerability of selected communities in the Caribbean. However, as Jamaica and Suriname had selected communities for the pilot phase hitherto unvisited by the Red Cross, fresh VCAs were conducted in those communities. Antigua and Barbuda used the VCA assessments from the recent past.

3. The CCCA Toolkit developed by the Resource Center in Barbados was implemented to assess the perception of risk from climate change impacts among community members. The survey assisted in the guidance of micro-project identification and development.

**Institutional agreement with Florida International University**

The IFRC signed an institutional agreement with Florida International University for assessment, design, and implementation of the Cost Benefit Methodology for community-based DRR interventions to be implemented in the pilot phase of the Red Cross Project in
January 2013. The collaboration undertaken by the FIU-DRR Program was supported by USAID at no cost to the IFRC.

**Implementation Process for the DRR Interventions**

This section explains the general plan initially designed by the IFRC for the implementation of the DRR interventions.

The process of implementation of the Safer Shelters Component under Output 1 differed from that of the micro-projects under Outputs 2 and 3 in Antigua & Barbuda and Suriname (Figure 1). The decision to implement the Safer Shelters Component in Jamaica had been finalized at the beginning of the pilot phase by the Red Cross. Upon selection of communities using the CST, vulnerable households were selected and the retrofitting of the houses commenced. The CBA was conducted in the initial stages of the implementation of the intervention in July and August 2013. The Safer Shelters Component was completed by March 2014.

The process of selection of DRR micro-projects and their implementation in Antigua & Barbuda and in Suriname under Outputs 2 and 3 followed a different plan that had been developed by the IFRC (Figure 1). This initial plan which encouraged active decision-making by the community for DRR micro-project selection was as follows:

1. The results from the baseline KAP surveys, VCAs, and the CCCA Toolkit would be shared with the community members by the project managers and field officers of each National Society. Each community would then collectively draw a list of possible micro-project options for implementation to address the risks their community faced.

2. All the possible micro-project options would be analyzed using cost benefit methodology.

3. The results of the CBA would be presented to the community members who would then finalize approximately three micro-projects per community through collective decision-making.

In practice, the IFRC found that time and resource constraints did not allow a cost benefit analysis of all micro-project options. The planned process of DRR micro-project selection by communities upon review of survey assessments and cost benefit analysis did not materialize as envisioned either. By the time FIU was brought into the pilot phase of the Red Cross project, the IFRC had made the decision to restrict the CBA to certain micro-projects.

a) In Jamaica, the Safer Shelters Component was included for CBA. The component was part of Output 1 of the Red Cross Project and was being implemented in 5 communities in Jamaica alone. The DRR micro-project...
options for Outputs 2 and 3 in Jamaica were excluded from the CBA.

b) In Antigua and Barbuda, community members had identified several issues of concern for the communities. Three DRR micro-projects were finalized as solutions by the project manager in consultation with government officials and experts. The IFRC assigned two out of the three DRR micro-project options for CBA: the Diamond Hole Restoration Micro-project and the Vector Control Micro-project.

c) In Suriname, several options for DRR micro-projects were suggested by the project manager on behalf of the community members. However, some of the options were deemed unfeasible by the IFRC and only two micro-projects, Greenhouse Farming and Rainwater Harvesting, were finalized and assigned for CBA. Upon completing the CBA, these micro-projects were implemented in Coronie, Saramacca, Coppename, and Commewijne.

4. The DRR micro-projects were implemented in the 13 communities from January 2013 to March 2014 (Figure 1, Timeline).

5. Endline KAP surveys were conducted to compare results with the baseline surveys. The comparison assisted in recording noticeable changes in knowledge, attitude or practices of community members with regard to climate change awareness, health and other disaster risks. Ideally, the analysis would examine whether any of the changes could be attributed to the project interventions at the community level.

FIU-DRR PROGRAM'S STUDY: COST BENEFIT ANALYSES OF COMMUNITY-BASED DRR INTERVENTIONS IN THE CARIBBEAN

Objectives of the Institutional Agreement

On being approached by the IFRC, the Disaster Risk Reduction Program of the Florida International University (FIU) signed an agreement with the IFRC to develop a methodology for cost benefit analysis for the pilot phase of the Red Cross project, “Improving Climate Change Resilience of Caribbean Communities”. The community-based DRR Project was implemented in Antigua & Barbuda, Jamaica, and Suriname; it involved three outputs: retrofitting of vulnerable houses against windstorms, disaster risk reduction micro-projects against climate change impacts, and increased community disaster resilience through improved health. On the part of FIU, the agreement involved four outcomes:

1. Understanding of the project within the institutional and community setting.

2. Development of a CBA methodology and related forms.

3. Regional training of the three Red Cross National Societies.
4. Support in implementation of methodology and verification of the results.

According to the terms of the agreement, FIU’s DRR Program was to conduct the CBA of the DRR interventions between April and November 2013. During this time, informational support was provided by the IFRC Project Manager, Ms. Pryiadarshni Rai (at IFRC, Port of Spain, Trinidad), who was coordinating the Red Cross Project at the regional level.

1. Overview of the project within the institutional and community setting

To fulfill the first outcome of understanding the project within its institutional and community setting, a ten-day field trip to Jamaica, Antigua, and Trinidad was undertaken by the DRR program at FIU in April 2013. The main purpose of the initial visit was to gather information about the DRR interventions and consult with local project managers and stakeholders. The visit began with informational sessions with the IFRC Project Manager in Trinidad on the background of the project and a review of the findings of the baseline surveys that had been conducted for the project. These surveys and assessments had been conducted at the beginning of the project to determine the level of risk for each community and the perception of risk among community members.
In Jamaica, interview sessions were held with Red Cross officials, the project manager, and the field officer to gain information on the background and financial aspects of the Safer Shelters Component. Field trips to three different communities included inspection of the status of vulnerable homes, interviews with community members, key informants and local officials, and a visit to a ‘model’ house retrofitted under the intervention. Group meetings with members of vulnerable communities revealed the viewpoints and concerns of the stakeholders. Concern among community members for natural disaster risk and risk reduction measures is considered a good indicator of development of community resilience (Venton et al., 2009). In addition, Safer Houses Methodology which guided the home retrofits was reviewed.

In Antigua & Barbuda, visits to three communities were made to understand the nature of the disaster risks and the proposed DRR micro-projects. Information about each community was gathered from observations and informal conversations with the project manager. For example, for the health project in the communities of York and Piggotts in Antigua, it was possible to relate the high prevalence of mosquitoes on the island to the topography of the geographical area that promoted water stagnation and to the presence of uncovered water storage tanks that could be seen in each household.

In all, the primary aim of the visits to the Caribbean communities was fulfilled by studying the nature of the disaster risk in each community and analyzing the details of the proposed DRR micro-projects along with the associated financial and social costs of the projects. The exploratory field visits assisted in effectively formulating the methodologies for cost benefit analyses for the DRR interventions.

2. Development of a CBA methodology and related forms

Relevant cost benefit analysis and cost effectiveness analysis methodologies were developed for each intervention in the month of May by the FIU-DRR Program. The methodologies were developed using the information on costs gathered from the field visits described above and from extensive literature review.

3. Regional training of the three national societies

To achieve the third outcome of the agreement with IFRC, a regional training of twelve project managers, field officers, and financial officers of four Red Cross National Societies was conducted by the FIU-DRR Program in the first week of June 2013 in Port of Spain, Trinidad. The five-day training was also attended by representatives of the IFRC in Trinidad, Caribbean Disaster Management and Health Networks, and CADRIM (The Red Cross Disaster Risk Management Resource Center). The coursework for the training involved introduction to theory and concepts of CEA and CBA, exercises based on case
studies on how to apply CEA and CBA methodology, and the interpretation, analysis, and communication of the results of such economic analyses. The specific methodology for each micro-project in the three countries was then shared with each of the National Societies.

4. Support in implementation of methodology and verification of the results

In the months following the training, the project managers of the National Societies were to implement the given methodologies for each of the micro-project with active support from FIU. However, the DRR Program at FIU moved from a supporting role to leading the CBA implementation through regular and weekly communications with limited help from the project managers of the National Societies. The results of the economic analyses were completed and shared with the IFRC Project Manager between July and October 2013.
The objective of this study was to conduct ex ante economic analyses of the proposed community-based DRR interventions in 13 communities in the Caribbean.

**COST BENEFIT AND COST EFFECTIVENESS ANALYSIS OF DRR PROJECTS**

To develop a framework for cost benefit analysis or cost-effectiveness analysis of a DRR project, two scenarios are compared: hazards and their impacts on the community ‘without’ any DRR measures, and hazard impacts ‘with’ the DRR measures. The benefits accrued from the DRR project are calculated by subtracting the potential hazard impacts with the DRR measures from the potential hazard impacts without DRR measures. The resultant reduction in losses is taken as the benefits derived from the DRR measure. These benefits are now compared to the costs incurred from implementation of DRR project. If the benefits are quantified in monetary units, a cost benefit analysis can be carried out to yield a Benefit Cost Ratio (BCR). If benefits cannot be quantified, a cost effectiveness analysis is used to yield a cost effectiveness ratio (CER).

**Cost Benefit Analysis**

Cost benefit analysis is an economic tool that compares costs incurred and benefits accrued in the lifetime of a project to calculate the economic efficiency by generating indicators such as benefit cost ratio (BCR) and net present value (NPV).
Cost Effectiveness Analysis

Cost effectiveness analysis (CEA) is often used to assess projects by setting an objective and making cost comparisons between different options available to meet that objective. A CEA can assist in making choices among projects or options within a project. It is a useful economic tool when monetized benefits are not available, data is insufficient, and time and resources are at a premium. Cost-effectiveness is a simplified approach to economic analysis and can be employed by a wider group of people on the ground.

The analyses of the DRR micro-projects in this study were carried out using cost benefit and cost effectiveness analyses, depending on the data availability for each intervention. The general methodology of the study was as follows:

1. Definition of study parameters: The primary hazards for each community under focus of the present study are defined for each case study in Chapter 4. Although there are several hazards to which the Caribbean communities are exposed to, this study defined only the hazards and impacts that were within the scope of the analysis. In Jamaica, windstorms and low level flooding from heavy rainfall were the main hazards addressed by the Safer Shelters Component and the CBA study. The primary hazards for the communities in Antigua were sea level rise and flooding as a result of storm surge and heavy rainfall. In Suriname, impacts of sea level rise and salt water intrusion were the primary hazards. Climate change is projected to increase the intensity, frequency, or distribution of all these hazards.

   In the case studies of micro-projects implemented in Antigua and Barbuda and in Suriname, the micro-project implementation process is described followed by details of the proposed intervention.

2. Data collection: This section describes how the information on the hazard and impacts relevant to the study area was collected. The process of how the risk management option or the DRR project was identified is given in the section on micro-project implementation process. For the case study of the Safer Shelters Component, the background, objectives, and timeline of the intervention are provided.

3. Estimation of costs and benefits: This study took into account all financial as well as social costs that were accrued during the course of the project. The social costs
taken into consideration were mainly the opportunity costs incurred by community members who gave their time and skills towards the implementation of the projects.

Quantitative as well as qualitative benefits were identified. Quantitative benefits to which monetary values could be attached were estimated to calculate the economic efficiency of the project for the cost benefit analysis. Qualitative benefits that could not be monetized were identified in the analysis.

4. Cost Benefit Analysis or Cost Effectiveness Analysis

The above data on costs and benefits estimates were combined to calculate the economic efficiency of each micro-project. Based upon the availability of estimates on benefits, CBA was conducted if monetized estimates of benefits were available. In the case of the Vector Control micro-project in Antigua & Barbuda, a CEA was considered appropriate as monetary benefits could not be estimated.

Both CBA and CEA included quantitative and qualitative assessments. Quantitative analysis included the calculation of indicators such as BCR and the net present value (NPV) for CBA and CER for CEA. For the qualitative analyses, benefits that could not be monetized were identified.

**Indicators in CBA and CEA**

**Benefit Cost Ratio (BCR)**

The BCR is the ratio of benefits to costs of the project, both expressed in monetary terms and discounted present values. A BCR of one indicates that benefits are equal to costs. A value above one for BCR is usually an argument for the project to move ahead.

**Net Present Value (NPV)**

The NPV is the difference between the present values of the benefits and costs of the entire project. If the value of the NPV is above zero, it indicates that benefits outweigh the costs and hence the project can be considered viable. The higher the value of NPV, the stronger is the case for the project.

**Cost Effectiveness Ratio (CER)**

The CER is the ratio between the costs incurred by the project and its units of effectiveness. Units of effectiveness are a measure of any significant and quantifiable outcomes of the project.
The appropriate time horizon for each case study was chosen based upon the DRR measure. The current accepted rate of the central bank of each country was selected as the discount rate for each intervention. These results were shared with the IFRC. Thereafter, alternate discount rates of 3%, 5%, 7%, and/or 10% were used to determine the effect of varying discount rates on the BCR.

Benefits were discounted over the lifetime of the project. Costs were not discounted as they were accrued over the course of one year.

**Sensitivity Analysis:** Sensitivity analyses are conducted to address the key uncertainties in the values used in the analysis. This could be the value of discount rate used, the duration and intensity of the hazard, or the project lifetime assumed, etc. In sensitivity analyses, individual values are changed while keeping the other values constant to test how different factors affect the economic analysis.

5. **Recommendations based on economic analysis**

   The study recommended whether or not the economic analysis justified the implementation of the DRR intervention.

There were several challenges associated with the analyses of the DRR projects in the Caribbean:

1. The main challenge was the unavailability of suitable site-specific data for hazards and their impacts. For instance, community level data on hurricanes and wind impacts was required for the analysis of the Safer Shelters Component in Jamaica. However, because of unavailability of data at the local level, benefit transfer method was used.

2. The Safer House Methodology which designed the retrofits for the vulnerable homes in the Jamaican communities did not provide estimates of the level of protection offered by the retrofits. Therefore, to predict the reduction in losses ‘with’ the DRR measure, the study employed the benefit transfer method by using the average annual loss (AAL) values from a similar study in St Lucia by Hochrainer-Stigler et al. (2009). The lack of this information strongly influenced the results of the analysis.
3. There were significant qualitative benefits and social impacts from the micro-
projects which could not be quantified and therefore not reflected in the BCR. There is a danger in simply using the BCR or CER as the lone measure of the project’s success or failure. Therefore, our study considered the qualitative benefits and social impacts while making recommendations in the final analysis.

4. In addition, the study did not identify the distributional aspects of the benefits generated by the projects. This analysis is recommended for the ex post study of the projects.
Chapter 4 is divided into five sections. Each section presents the case study of the CBA or CEA of a community-based DRR project in the Caribbean, based on the methodology described in Chapter 3 with modifications based on the needs and characteristics of each intervention.

**Section 1: Cost Benefit Analysis (CBA) of Safer Shelters Component in Jamaica**

*Safer Shelters Component*

Country: Jamaica

Name of the intervention: Safer Shelters Component of the Red Cross Project

Number of communities served: Five (Windsor, Prospect, Flint River, Gully Road, and Killancholly)

**INTRODUCTION**

Jamaica experiences frequent hurricanes, floods, landslides, and droughts. Between 2001 and 2008, Jamaica suffered eight major events that caused estimated damages and losses worth USD 1.1 billion. Sixteen percent of the Jamaican population was affected by weather related disasters in the period of 2000–2009, suffering 50 fatalities (EM-DAT database). The most vulnerable segment of the population is the 16% which lies below poverty line (CIA Fact Book estimate 2009). Low level (less than 1 m) flooding is common.

Housing vulnerability is created in the Caribbean by a lack of building codes and/or its enforcement, low knowledge/ awareness/ risk perception and capacity in the informal
building sector, difficulties in enforcing zoning or land use regulations, and squatting and land tenure issues. In contrast, houses that are built to code are able to withstand the effects of hurricane impacts as observed in Jamaica during Hurricane Dean and Grenada during Ivan in 2004. Similarly, stronger shelters survived the impacts of Hurricane Irene, a category 3 storm in the Bahamas (IFRC Proposal, 2011).

**THE SAFER SHELTERS COMPONENT**

The Safer Shelters Component was part of Output 1 of the Red Cross project and was implemented in Jamaica alone. The Safer Shelters Component was a predetermined part of the Red Cross Project, i.e., its implementation did not hinge upon the results of the CBA. Unlike the DRR interventions in Antigua and Barbuda and in Suriname for Outputs 2 and 3, the Safer Shelters was not finalized upon analysis of KAP surveys and VCAs or through community participation as were the DRR micro-projects. It was not considered a micro-project for the size, budget, and scope of its application in five communities.

Retrofits inside a ‘model’ house in Jamaica
*Photo courtesy Meenakshi Jerath*
Objectives

In the past, the Red Cross Movement’s shelter program in the Caribbean had been mainly reactive, focusing on rebuilding shelters post disaster. However, the Safer Shelters Component was designed as a proactive mitigation measure by the Jamaica Red Cross (JRC). The goals were:

1. To address the impacts of hurricane winds and flood impacts on vulnerable homes in selected communities.

2. To use established shelter tools with best construction practices and shelter assistance to vulnerable houses in the communities.

3. To provide the communities with resources and knowledge skills for the application of building techniques that make vulnerable homes safer against hurricanes and floods.

4. To retrofit selected vulnerable houses in a participatory, learning by doing approach so as to educate the wider community by example and further advocate for an expanded safe shelter program at the national level.

5. To implement the project in partnership with social and community services, and the national building authority.

The objectives were:

- Community members will retrofit 10 vulnerable homes in five communities each.

- Construct entryway flood barriers in 5 households in two communities for protection against <1m flooding. This will also lead to awareness about flood protection among other community members. The use of the flood barriers will be linked to simple community flood early warning system and response plan.

- Rebuilding of homes.

- The Resource Center at Barbados will publish the safer shelters brochures and flood barrier guidelines.

By October 2013, the Component had revised its plans to retrofit 76 vulnerable houses in 5 communities to provide protection against hurricane wind impacts. Flood barriers were also installed in 26 of these 76 homes that are vulnerable to flooding during times of heavy rainfall. Six homes were completely rebuilt.
Selection of communities

Five communities located in the northeast region of the island state of Jamaica were selected for the Safer Shelters Project using the Community Selection Tool. The communities were Windsor, Prospect, Flint River, Gully Road, and Killancholly.

Safe House Methodology

A Shelter Delegate with technical skills for retrofitting and rebuilding houses was assigned to first develop the Safer Shelters Methodology for Jamaica. A national Safe House Training was then conducted to train 20 community volunteers including technical staff of housing departments, ministries, and local NGOs to become facilitators. These facilitators in turn carried out the implementation of the project by retrofitting the houses themselves under the supervision of the Shelter Delegate. Alongside, they would, by demonstration, educate the community members in the process of protecting their homes from windstorm damage.

The technical support for the Safer Shelters Component was provided by the Resource Center in Barbados. The project was expected to use the CDEMA building guide for artisans, CUBiC and other draft national codes. According to the information given by the Jamaica Red Cross to the cost benefit analyst, the Safe house Methodology did not provide any technical specifications or regulatory codes used for construction and retrofitting material, or how these specifications were complied with. The guidelines of the Methodology also did not indicate the level of protection that would be offered by the retrofitted and rebuilt houses.
Selection of vulnerable households

The selection of vulnerable households for retrofitting and rebuilding was done by the Shelter Delegate during the preliminary process. Transect walks by the Shelter Delegate through the communities revealed the technical and social vulnerability of house structures and of the families therein. The criteria for selection included:

- Vulnerable homes in repairable condition (technical criteria)
- Homes of the disabled, elderly, HIV/AIDS affected (social criteria)
- Single mother families, extended family with babies (social criteria)
- Low income families (social criteria)

Home ownership was an additional criterion to qualify for receiving the benefit from the Safer Shelters Project.

Project Timeline

The Safer Shelters Component began in January 2013 and was completed in March 2014.

COST BENEFIT ANALYSIS OF THE SAFER SHELTERS COMPONENT

Study Parameters

Hurricane windstorms along with low level flooding are the primary hazards for the Jamaican communities. As the impact of flooding is relatively small, this study will focus its analysis on windstorms and wind damage to houses in the five Caribbean communities.

Data Collection

No independent site specific assessments were made for hazard assessments or impact assessments. These assessments were based on existing literature. Data on costs associated with the intervention were collected during the field visits to the communities in Jamaica and through information shared by the project officer in Jamaica Red Cross National Society. Benefits were estimated using the benefit transfer approach.

Estimation of Costs and Benefits

Costs: This study took into account all costs incurred by the project – financial as well as social or opportunity costs. The financial costs included all the actual costs that were incurred for construction materials, tools, labor, training, food, transportation, office
supplies, and maintenance. Social costs are costs that are not actually incurred by the project but are opportunity costs to certain members of the community. These included the opportunity cost of time and skills donated by consultants, shelter delegates, shelter facilitator, and volunteers.

The project was divided into Phase 1 (Investment Phase), Phase 2 (Operating Phase), and Phase 3 (Completion Phase). The investment costs for Phase 1 were $21,630; operating costs for Phase 2 were $56,280; costs for the third phase during which operations continued were $52,750. The social costs accrued to the community for the entire project were $12,944 (Table 2).

Costs were divided based on the two outcomes of the Safer Shelters Component: Retrofitting of Houses and Rebuilding of Houses. The financial costs for retrofits were $47,741 and $82,919 for home rebuilding. The social opportunity costs for the entire project ($12,944) were divided equally between the two outcomes. As a result, the final costs (financial and social) for Retrofits and Rebuilding were $54,213 and $89,391, respectively (Table 2).

Benefits: In the absence of site specific data on hazard and impacts for the Jamaican communities, the benefit transfer method was employed to estimate the benefits for the Safer Shelters Component. In a benefit transfer approach, the existing estimated value for benefits based on an original ‘study site’ is transferred and applied to the ‘policy site’. The benefit transfer method is employed when time and resources are a constraint for data gathering or when suitable data is unavailable (Plummer, 2009).

The study by Hochrainer-Stigler et al. (2011) on home retrofits against wind impacts in St. Lucia was used for the benefit transfer approach. St. Lucia was considered a suitable ‘study site’ as it is a small island state in the Caribbean just as Jamaica (‘policy site’) (Table 2).

Cost Benefit Analysis

A social CBA was conducted for the Safer Shelters Component in which the goal was to assess the impact of the project on all members of the communities. Two outcomes of the project are considered for cost benefit analysis: (1) Retrofitting of vulnerable houses against windstorm impact, and (2) Rebuilding of houses.

1st DRR measure: Retrofitting of Vulnerable Houses

The financial costs for retrofitting 76 homes against wind impact and against storm water flooding were $47,741. We estimated that the effectiveness of the retrofits will last for the next five years. The benefits were estimated as the expected risk from the annual average
loss values (AAL) experienced by a wood frame house in a maximum hazard area with respect to a 5 year hurricane. The benefit gained or the expected risk per house per year was calculated as $154.

Using the discount rate of 2% (http://www.indexmundi.com/jamaica/central_bank_discount_rate.html), the benefit cost ratio (BCR) of retrofitting 76 homes in Jamaica was 1.15, with a gain in net present value (NPV) of $7,304. With all the opportunity costs involved in the project (the opportunity costs for the project being $6,472) accounted for, the BCR for retrofitting houses against wind impacts and flooding was 1.02, with a gain in NPV of $832 (Table 2).

2nd DRR Measure: Rebuilding of Houses

The financial costs for rebuilding 6 safe homes against wind impact and storm water flooding were $82,919. It was estimated that the houses would provide protection against wind impacts for the next ten years. The benefits were estimated as the expected risk from the annual average loss values experienced by a wood frame house in a maximum hazard area with respect to a 10 year hurricane. The benefits gained or the expected risk per house per year was calculated as $241.

Using the discount rate of 2% (http://www.indexmundi.com/jamaica/central_bank_discount_rate.html), the benefit cost ratio (BCR) of rebuilding 6 houses in Jamaica was 0.16, with a net present value (NPV) of (-$69,906). Along with the opportunity costs involved in the project (the opportunity costs for the project being $6,472), the BCR for rebuilding 6 houses against wind impacts and flooding was 0.15, with a NPV of (-$76,378) (Table 2).

Sensitivity Analysis

Owing to the absence of information available on the level of protection offered by the Safer House Methodology, this study had assumed that the retrofit provided protection for a 5 year hurricane. The assumption was varied for sensitivity analysis. The study analyzed results for a 10 year horizon for the retrofitting of houses and rebuilding of houses (Table 3). Assuming that the retrofitting of houses lasts 10 years, the BCR of the intervention was 2.20 (financial) and 1.93 (social) and the NPV was $57,159 (financial) and $50,687 (social) (Table 3). Sensitivity analysis was also done using alternate discount rates (5% and 10%) (Table 3). It was observed that the BCR was highest for retrofitting of houses when the benefits are assumed for 10 years using financial costs alone with a discount rate of 2% (relevant to Jamaica’s Central Bank).
Recommendations

The financial BCR of 1.15 for retrofitting of houses in the five communities in Jamaica indicated that the benefits were higher than the costs, although by a small margin. The donor agency (DFID) was expected to receive the return on its investment with an NPV of $7,304. The BCR was 1.02 when the social costs were taken into account. In this case too, the benefits were higher, though only slightly so, and by an NPV of $832. By taking into account the economic indicators of the financial BCR and NPV alone, the project is justified.

Along with retrofitting of 76 houses, 6 houses were rebuilt by the Safer Shelters Component. The financial and social BCR for this DRR measure were below 1 (0.16 and 0.15, respectively) indicating that the project was not viable. The project would also result in loss in net present value terms (-$69,906 for the financial analysis and -$76,378 for the social analysis).

It is important to note that a robust analysis of the benefits could not be made for either retrofitting or rebuilding of houses. Minimum benefits were assigned to the interventions as the Jamaican Red Cross did not provide FIU-DRR with information on technical specifications and regulatory codes followed by the Safe House Methodology, or the level of protection that the interventions offered.

However, the qualitative benefits that were expected to arise out of retrofitting vulnerable homes are significant. The following benefits were expected but not quantified in this analysis:

1. The DRR project in disaster risk communities in the five communities in Jamaica especially targeted the socially vulnerable members of the society: the elderly, low income families, single mother families, HIV/AIDS affected, and the disabled. These socially vulnerable members of the society will clearly be the beneficiaries in particular, and the society is expected to benefit at large.

2. It was expected that the retrofitted homes would provide benefits to community members in terms of reduction in losses because of a) lost household possessions, b) lost work days and school days, and c) reduction in injuries suffered during the disaster event. These benefits could not be quantified for the lack of available data but their value is significant and clearly demonstrates a positive effect on the society.

3. The retrofitted and rebuilt houses were expected to have a replicating effect on the rest of the community. The retrofitted and rebuilt homes would serve as models for the other members of the community who would be encouraged to make similar
upgrades to protect their properties against potential hurricane winds. The replicating effects would lead to real benefits for the community in the long-term as more and more households would be protected against windstorm damage.

4. The DRR intervention involved the training of community members in retrofitting and rebuilding houses based on the Safer House Methodology. These members in turn implemented the methodology through retrofitting 76 houses and rebuilding 6 houses in Jamaica. The new skills acquired and the level of experience gained were significant benefits not monetized by this study. Trained members will not only be able to benefit personally through the acquired skills, but will in turn be able to train other members of society as well. For instance, one of the trained members that the CBA analyst met during the field visit had already begun to practice his newly acquired skills to expand his business.

5. The training of community members in retrofitting and rebuilding of safer shelters, the involvement of young members of society in conducting surveys and assessments, the conducting of community level meetings to discuss project options was expected to lead to an overall increase in education and awareness on DRR related issues. This benefit was not monetized and should be considered invaluable in making the community more resilient, the ultimate goal of the Red Cross project.

All these benefits – monetary as well as non-monetary –demonstrated that the Safer Shelters Component would have a positive impact on the five communities in Jamaica.
### Table 2: Cost Benefit Analysis of Safer Shelters Component, Jamaica

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Windstorms and flooding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Scope</td>
<td>Windstorm damage to household structures</td>
</tr>
<tr>
<td>Communities</td>
<td>5 (Windsor, Prospect, Flint River, Gully Road, and Killancholly)</td>
</tr>
<tr>
<td>DRR Measure</td>
<td>Safer Shelters Project includes two DRR Measures:</td>
</tr>
<tr>
<td></td>
<td>a. Retrofitting of houses (A); b. Rebuilding of houses (B)</td>
</tr>
<tr>
<td>Costs</td>
<td>DRR Measure</td>
</tr>
<tr>
<td></td>
<td>Number of homes</td>
</tr>
<tr>
<td></td>
<td>Financial Costs</td>
</tr>
<tr>
<td></td>
<td>Social Costs</td>
</tr>
<tr>
<td></td>
<td>Financial + Social Costs</td>
</tr>
<tr>
<td></td>
<td>Total Financial Costs of the Entire Project (A and B)</td>
</tr>
<tr>
<td></td>
<td>Total Financial and Social Costs of the Entire Project (A and B)</td>
</tr>
<tr>
<td>Benefits</td>
<td>Quantitative</td>
</tr>
<tr>
<td></td>
<td>AAL per house in study site</td>
</tr>
<tr>
<td></td>
<td>Expected Risk per house in study site</td>
</tr>
<tr>
<td></td>
<td>AAL per house in ‘policy’ site</td>
</tr>
<tr>
<td></td>
<td>Avoided loss from risk reduction per house in policy site</td>
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Total Expected Risk Reduced/Expected Benefit in policy site

<table>
<thead>
<tr>
<th></th>
<th>$11,678</th>
<th>$1,449</th>
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<tbody>
<tr>
<td>Qualitative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced loss of household possessions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction in workdays and schooldays lost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction in medical visits for injuries</td>
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### Cost Benefit Analysis

<table>
<thead>
<tr>
<th></th>
<th>Retrofitting of houses (A)</th>
<th>Rebuilding of houses (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time horizon</td>
<td>5 years</td>
<td>10 years</td>
</tr>
<tr>
<td>Discount Rate</td>
<td>2%</td>
<td>2%</td>
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#### Financial CBA

<table>
<thead>
<tr>
<th></th>
<th>$47,741</th>
<th>$82,919</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benefits (discounted)</td>
<td>$55,045</td>
<td>$104,900</td>
</tr>
<tr>
<td>BCR</td>
<td>1.15</td>
<td>2.20</td>
</tr>
<tr>
<td>NPV</td>
<td>$7,304</td>
<td>$57,159</td>
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</table>

#### Social CBA

<table>
<thead>
<tr>
<th></th>
<th>$54,213</th>
<th>$89,391</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benefits (discounted)</td>
<td>$55,045</td>
<td>$104,900</td>
</tr>
<tr>
<td>BCR</td>
<td>1.02</td>
<td>1.93</td>
</tr>
<tr>
<td>NPV</td>
<td>$832</td>
<td>$50,687</td>
</tr>
</tbody>
</table>

1: AAL=Average Annual Loss; 2: Study Site is St. Lucia, values from Hochrainer-Stigler et al. 2010; 3: Policy site = Jamaican communities
Table 3: Summary of Sensitivity Analysis for Discount Rate in the CBA of Safer Shelters Component

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>Retrofitting of houses</th>
<th>Rebuilding of houses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2%</td>
<td>5%</td>
</tr>
<tr>
<td>5 year Financial</td>
<td>1.15</td>
<td>1.06</td>
</tr>
<tr>
<td>Social</td>
<td>1.02</td>
<td>0.93</td>
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<tr>
<td>10 year Financial</td>
<td>2.2</td>
<td>1.89</td>
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<tr>
<td>Social</td>
<td>1.93</td>
<td>1.66</td>
</tr>
</tbody>
</table>

Section 2: Cost Benefit Analysis (CBA) of Diamond Hole Dam Restoration

Diamond Hole Dam Restoration

Country: Antigua & Barbuda

Name of the DRR micro-project: Diamond Hole Dam Restoration

Number of communities served: One (Bendals)

INTRODUCTION

The Diamond Hole Dam is a part of a series of water catchments that provides irrigation water to 17 active, small-sized farms in Antigua. The dam has an optimum holding capacity of 5MG (million gallons) and yields over 20 - 25MG of water per year. The metal plates upon which the dam wall is constructed had corroded, reducing the holding capacity of the dam and decreasing the irrigation water supply to the farms served. As a result, the farming community in Bendals community was experiencing acute water shortage during the dry season although the water supply in the rainy season was sufficient for farming. In addition, the reduced holding capacity of the dam reservoir led to the flooding of the residential areas in the community downstream.

MICRO-PROJECT IMPLEMENTATION PROCESS

The process of the selection of Diamond Hole Restoration micro-project and its implementation followed the IFRC plan described in Chapter 2 (see Figure 1) with some deviations.

The Community Selection Tool was used to identify Bendals as a community for DRR micro-project implementation under Output 2 in the Red Cross Project.
The CCCA toolkit and baseline KAP surveys were conducted in the community. As indicated by the initial IFRC plan, assessments from VCAs that had been previously conducted were utilized. The CCCA toolkit in particular helped identify the primary problems of flooding and drought. Discussions under the CCCA toolkit application yielded the identification of this micro-project as a possible solution. The community members did not draw a list of possible micro-project options from which to choose from. As the restoration of the dam addressed the primary problems of drought and flooding for the community, the IFRC proceeded and assigned the Diamond Hole Restoration micro-project for CBA. Upon receiving the results of the analysis, the micro-project was implemented. This was followed by the endline surveys.

THE DRR MICRO-PROJECT: DIAMOND HOLE DAM RESTORATION

The plan for Diamond Hole restoration and refurbishment was developed as a result of the integration of CCCA Toolkit into the VCA process. Community discussions focused on drought and flooding as priorities and the restoration of the dam was thus developed as a solution.

Objectives

The objective of the proposed micro-project was to waterproof and refurbish the corroded plates at the base of the dam wall. By doing so, the micro-project aimed to increase the quantity of potable water for irrigation purposes for the 17 agricultural farms that it feeds. Additionally, potable water would be supplied during the 6 month rainy season to residents of Bendals for household use. It was expected that the increase in the holding capacity of the dam would likely reduce the quantity of water that flowed downstream and flooded the Bendals community. Reduction in soil erosion at the outflow side of the spillway was another expected outcome of the micro-project.

COST BENEFIT ANALYSIS OF DIAMOND HOLE DAM RESTORATION

Study Parameters

During the process of the implementation of the CCCA Toolkit, drought in the dry season and flooding in the rainy season were identified as primary hazards. This study will focus its analysis on the shortage of water created in the dry season as a result of the malfunctioning dam. The impacts of flooding and soil erosion will not be analyzed by this study.
Data Collection

The information on the hazard and impacts of drought and flooding in the Bendals area because of the corrosion of the metal plates in the Diamond Hole dam was limited by the data available. Time and resource constraints, too, did not allow for gathering site-specific information. Information on the technical and functional features of the Diamond Hole dam, and impacts on agricultural activities with and without the intervention were obtained using existing data sets from the Antigua Public Utility Authority and the Environment Division along with expert consultation. This necessary information was obtained through consultation with public officials and experts by the Antigua and Barbuda Red Cross (ABRC) project manager.

Estimation of Costs and Benefits

Costs: The analysis estimated financial costs for the project along with opportunity costs incurred by the community members. The financial costs included all the actual costs that were incurred for construction materials, tools, labor, training, food, transportation, office supplies, and maintenance. Social costs included the opportunity cost of time and skills donated by volunteers, engineering consultants, skilled and unskilled workers, office space used, construction material donated, and the engineering report produced. The opportunity

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2 Consultation: (1) For site clearance, refurbishment, mobilization of farmers: Extension Division of the Ministry of Agriculture; (2) For pre and casting operations labor, and engineering experts: Bendals Community Group; (3) For site clearance, material, overall coordination of project: Antigua and Barbuda Red Cross (ABRC).
costs for this micro-project were particularly high for three reasons: a) large donations for construction material and its transport by companies, b) significant contribution by engineering experts, and c) overwhelming support by community members as volunteers.

The total financial costs were $27,294 and the opportunity costs were $50,899. This led to total estimation of $78,192 for the discounted costs for the restoration of the dam.

Benefits: This study used the market value of the agricultural production of the Bendals farming community, and the value of potable water in Antigua and Barbuda to estimate benefits.

As noted earlier, the malfunctioning dam did not supply adequate amount of water for irrigation to the 17 small-sized farms in Bendals. Farmers were unable to achieve optimal crop yield during the 6-month dry season in contrast to the rainy months. Upon restoration it was expected that sufficient amount of water for irrigation would be available to the farmers in the 6-month dry period. This would be in addition to the irrigation supply that the farmers received for the rest of the year.

The first estimated benefit was based on the change in the market value of the agricultural yield that the farmers were expected to produce upon restoration. The value of the agricultural yield from the 17 farms without the micro-project was $1 million per year. Post restoration, it was expected that there would be an increase in the potable water supply in the dry season resulting in an additional season for crop growth in the growing year. Based on estimates given to the Antigua & Barbuda Red Cross project manager by experts in the Ministry of Agriculture, the increased water supply would lead to an additional income of $1.2 million for the 17 farms by. To keep the estimate moderate, it was assumed that the increase in irrigation would increase the value of agricultural production from $800,000 to $1.2 million. This would lead to net benefits of $800,000 to $1.2 million per year.

The second benefit estimated for the Diamond Hole Restoration micro-project was based on the value of the increase in potable water supply for household use for the 2,131 residents of Bendals community. The restoration of the dam was expected to supply potable water for the 5 month rainy season to the community members of Bendals for household purposes. It was assumed that 72% of the total reservoir storage (Nissen-Petersen, 2006) from the refurbished dam would be available for household water supply. Using the value of potable water as used in Antigua & Barbuda government documents, the annual benefit arising from the Diamond Hole restoration was estimated at approximately $1,700 for the residents of the Bendals community (Table 4).
The restoration of the Diamond Hole Dam was expected to result in benefits beyond the ones quantified above. It was expected that the increased income from the agricultural production would lead to significant improvement in standard of living for the farming community. The households in the community would receive potable water for domestic use, raising their standard of living and providing comfort to the residents. The expected benefits from reduced flooding were reduction in losses from property and material damage along with improved standard of living for the community residents. Reduced flooding was also expected to improve community health by decreasing the incidence of diarrhoeal disease.

Cost Benefit Analysis

The total annual benefits from the Diamond Hole dam restoration were calculated by estimating two benefits: increased agricultural production and supply of potable water for household use in Bendals. The estimation of total annual benefits ranged from $816,805 to $1.2 million. Using the discount rate of 6.5% (http://www.indexmundi.com/antigua_and_barbuda/central_bank_discount_rate.html), the NPV and BCR of the micro-project were calculated. A conservative assumption was made that the dam restoration benefits would last for 10 years.

The financial cost benefit analysis indicated that the NPV from the dam restoration ranged from $5.8 to $8.7 million. The estimated financial BCR ranged between 215 and 320.

The social cost benefit analysis yielded the NPV range of $5.7 to $8.6 million. The social BCR was 75 to 112 (Tables 4 and 5).

Sensitivity Analysis

The analysis assumed a range of net benefits ($800,000 - $1.2 million per year) from increase in agricultural production even though the agricultural experts provided a single point estimated benefit of $1.2 million per year from increase in agricultural production. This range served as a sensitivity analysis for the estimated benefit for this analysis.

Further, we tested the discount rate using sensitivity analysis. In addition to the discount rate (6.5%) based on the central bank in Antigua and Barbuda, we used 10% discount rate for a lower estimate of BCR and 5% discount rate for an upper estimate of BCR (Table 5). When financial costs alone are taken into account, the BCR ranged from 184 (discount rate: 10%) to 215 (discount rate: 6.5%) to 231 (discount rate: 5%) when considering minimum benefit of $800,000 per year. When social costs are taken into account, the BCR ranges from 64 (discount rate: 10%) to 75 (discount rate: 6.5%) to 81 (discount rate: 5%) when considering minimum benefit of $800,000 per year (Table 5).
Chapter 4

Recommendations

Simply based on the financial cost benefit analysis, this micro-project was highly recommended for implementation. The BCR was exceptionally high (215 for financial CBA and 75 for social CBA) when considering minimum benefits. This micro-project was deemed highly feasible as the estimated NPV was approximately $6 million over 10 years.

Apart from the quantitative benefits, the micro-project was expected to yield several non-monetized qualitative benefits for the community members such as rise in the standard of living by decreased frequency of flooding, and greater income and employment from increased agricultural activity in the community.
Table 4: Cost benefit analysis of Diamond Hole Dam Restoration

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Drought, flooding, and soil erosion in Bendals community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope of CBA</td>
<td>Drought in the dry season</td>
</tr>
<tr>
<td>Communities</td>
<td>Bendals community (The positive impacts of the micro-project are expected to reach other communities as well)</td>
</tr>
<tr>
<td>DRR Measure</td>
<td>Diamond Hole Dam Restoration includes waterproofing and refurbishing of corroded metal plates at base of dam wall</td>
</tr>
<tr>
<td>Costs</td>
<td></td>
</tr>
<tr>
<td>Financial</td>
<td>$26,157</td>
</tr>
<tr>
<td>Social</td>
<td>$50,899</td>
</tr>
<tr>
<td>Total</td>
<td>$78,192</td>
</tr>
<tr>
<td>Net Benefits</td>
<td></td>
</tr>
<tr>
<td>Quantitative</td>
<td>Increase in market value of agricultural yield resulting from increase in irrigation supply (per year)</td>
</tr>
<tr>
<td></td>
<td>$800,00 (expected minimum)</td>
</tr>
<tr>
<td></td>
<td>$1.2 million (expected maximum)</td>
</tr>
<tr>
<td></td>
<td>Value of potable water for household use as a result of increase holding capacity of dam (per year)</td>
</tr>
<tr>
<td></td>
<td>$1,700</td>
</tr>
<tr>
<td>Total Net Benefits</td>
<td>$801,700 (expected minimum)</td>
</tr>
<tr>
<td></td>
<td>$1,201,700 (expected maximum)</td>
</tr>
<tr>
<td>Qualitative</td>
<td>Improved standard of living for residents as a result of:</td>
</tr>
<tr>
<td></td>
<td>reduced flooding</td>
</tr>
<tr>
<td></td>
<td>reduced loss from property and material damage</td>
</tr>
<tr>
<td></td>
<td>increased potable water supply for household use</td>
</tr>
<tr>
<td></td>
<td>increase in employment because of increase in agricultural activity</td>
</tr>
<tr>
<td>Cost Benefit Analysis</td>
<td></td>
</tr>
<tr>
<td>Time horizon</td>
<td>10 years</td>
</tr>
<tr>
<td>Discount Rate</td>
<td>6.50%</td>
</tr>
<tr>
<td>Financial CBA</td>
<td>BCR</td>
</tr>
<tr>
<td>Net Present Value (NPV)</td>
<td>$5.8 million</td>
</tr>
<tr>
<td>Social CBA</td>
<td>BCR</td>
</tr>
<tr>
<td>Net Present Value (NPV)</td>
<td>$5.8 million</td>
</tr>
</tbody>
</table>
### Table 5: Sensitivity Analysis – CBA of Diamond Hole Dam Restoration Micro-project

#### A. Financial Cost

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>Minimum benefits</th>
<th>Maximum benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Rate</td>
<td>5% 6.5% 10%</td>
<td>5% 6.5% 10%</td>
</tr>
<tr>
<td>NPV</td>
<td>6,279,857 5,844,577 4,991,618</td>
<td>9,368,429 8,720,110 7,449,676</td>
</tr>
<tr>
<td>BCR</td>
<td>231 215 184</td>
<td>343 320 276</td>
</tr>
<tr>
<td>IRR</td>
<td>2969% 2926% 2830%</td>
<td>4426% 4362% 4220%</td>
</tr>
</tbody>
</table>

#### B. Total (Social) Cost

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>Minimum benefits</th>
<th>Maximum benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Rate</td>
<td>5% 6.5% 10%</td>
<td>5% 6.5% 10%</td>
</tr>
<tr>
<td>NPV</td>
<td>6,228,836 5,793,679 4,940,950</td>
<td>9,317,530 8,669,211 7,398,777</td>
</tr>
<tr>
<td>BCR</td>
<td>81 75 64</td>
<td>120 112 96</td>
</tr>
<tr>
<td>IRR</td>
<td>1005% 989% 955%</td>
<td>1499% 1477% 1426%</td>
</tr>
</tbody>
</table>
Section 3: Cost Effectiveness Analysis (CEA) of Vector Control Micro-Project in Antigua and Barbuda

Vector Control Micro-project

Country: Antigua and Barbuda

Name of the Project: Vector Control Micro-project

Number of communities served: Two - Yorks and Piggotts

INTRODUCTION

The communities of Yorks and Piggotts in Antigua and Barbuda were identified as particularly vulnerable to flooding. The communities are so located that the neighboring water bodies, the McKinnon’s Pond and the Yorks’ waterway, would overflow and flood the neighboring residential areas during episodes of heavy rain. Storm surge during hurricanes raises the water levels of the water bodies resulting in stagnant water conditions throughout the communities. The proximity of the communities to the water bodies and the creation of stagnant water conditions in Yorks and Piggotts often led to an environment conducive to the proliferation of mosquitoes during the six months of rainy season.

The presence of Aedes aegyptii, the vector for dengue virus was of grave concern to the community. During the field visits to the communities, it was observed that most households stored water in cisterns, tanks or drums that were unprotected against mosquito access. It was estimated that the mosquitoes could easily access these water sources through drain and vent pipes. The project manager in consultation with health officials in the local government estimated that the mosquitoes had unobstructed access to 30% - 50% of possible breeding sites in the community.

MICRO-PROJECT IMPLEMENTATION PROCESS

The process of the selection of the vector control micro-project and its implementation followed the IFRC plan described in Chapter 2 (see Figure 1) with some deviations. Yorks and Piggotts were identified as communities of concern for the Red Cross Project through the Community Selection Tool (CST). Baseline KAP surveys along with the CCCA toolkit established mosquito proliferation as a result of stagnant water conditions as priorities to be addressed for community health. No other possible options were explored; the vector control micro-project was assigned for CBA. Upon receiving the results of the analysis, the micro-project was implemented. This was followed by the endline surveys.
THE DRR MICRO-PROJECT: VECTOR CONTROL MICRO-PROJECT IN ANTIGUA AND BARBUDA

This micro-project was part of Output 3 of the Red Cross Project which aimed to reduce health risks of the community through prevention of vector proliferation and increase in community health awareness by volunteer training and peer education.

Objectives

The Vector Control micro-project’s objectives was to control mosquito proliferation by reducing the number of breeding sites for the mosquito, *Aedes aegypti*, in three ways:

1. By reducing access of mosquitoes to stagnant water: This was done by eliminating mosquito access to open water storage containers. Covers for water harvesting containers, septic vents and gutters were distributed to the households in the community.

2. By killing the mosquitoes at the larval stage and adult stage: Fogging sessions to kill adult mosquitoes and larvicidal dunks to kill the larvae were employed.

3. By educating the community: Community residents were given information on how to inspect and assess their homes for mosquitoes, and on how to protect themselves from mosquitoes.

The micro-project provided equipment to the Central Board of Health (CBH) for the ‘Ladder Teams’ to operate. Community Volunteers and CBH Staff deployed larvicidal dunks in ponds and other stagnant/slow moving water sources. CBHFA Community Volunteers visited homes and educated homeowners on ways to assess and protect themselves from mosquitoes. Informational brochures were distributed.

COST BENEFIT ANALYSIS OF THE VECTOR CONTROL MICRO-PROJECT

Study Parameters

The primary health risk identified for community members of Yorks and Piggotts was mosquito proliferation. The study will focus its analysis on the potential health risk of dengue arising from mosquito proliferation.

Data Collection

Estimates for costs of the micro-project were given by the Antigua & Barbuda Red Cross project manager in consultation with government health officials in Antigua. The estimates for benefits were derived from extensive literature review.
Estimation of Costs and Benefits/Effectiveness

Costs: The cost of the one year vector control project in the communities of Yorks and Piggotts was estimated to be $17,678. This included costs for equipment, labour, and awareness programs.

Benefits/Effectiveness: In the absence of any preventive measures such as the Vector Control micro-project, incidence of dengue is likely and an outbreak is possible. Dengue incidence and prevalence are on the rise in tropical and sub-tropical regions of the world (PAHO 2007; San Martin et al., 2010; Dick et al., 2012). Dengue in the Americas has an endem-epidemic pattern with outbreaks every 3 - 5 years (Dicke et al., 2012). The benefits of the vector control micro-project, not measurable in dollar terms, were measured as units of effectiveness. Units of effectiveness are the desirable and quantifiable outcomes of a project.

The number of people protected against potential dengue infection in the communities of Yorks and Piggotts (through the provision of water storage covers, use of insecticidal sprays and larvicidal techniques, and awareness campaigns) was used as the effectiveness measure of the vector control program. This is a behavioural change indicator as used by Baly et al. (2007) for measuring the cost-effectiveness of the *Aedes aegypti* control programme in Santiago de Cuba.
The Vector Control Micro-project distributed 776 covers for water storage tanks, gutters, and septic vents. The communities were treated with insecticidal sprays to target adult mosquitoes while larvicidal dunks targeted the larvae. In addition, a strong public education and awareness campaign was implemented in the community. In sum, the study estimated that 2,145 residents in Yorks and 2,865 residents of Piggotts were the direct beneficiaries of the intervention, who were protected against potential dengue infection.

Cost effectiveness analysis

This study identified the benefits/effectiveness arising from the micro-project and measured them against its costs. A cost effectiveness ratio (CER) was obtained by dividing the costs by the units of effectiveness.

For the Yorks community, the cost effectiveness ratio was $4.12 per person protected against potential dengue infection, implying that it cost the micro-project approximately $4 to protect a community resident in Yorks against potential dengue infection.

For the Piggotts community, the cost-effectiveness ratio was $3.09 per person protected against potential dengue infection, implying that it cost the micro-project approximately $3 to protect a person against potential dengue infection in Piggotts.

The cost of protection can be compared to the cost of disease treatment estimated in other case studies found in literature. Suaya et al. 2007 estimated the average costs of hospitalized dengue cases to the public sector as $57.92 per hospitalized dengue case. Thus, the public sector would save $57.92 for every case of dengue averted in the communities of Yorks and Piggotts. In addition, a hospitalized case of dengue would cost a household $32.7, an ambulatory case would cost $10, and the income lost per hospitalized case for a household would amount to $19.6 (Suaya et al. 2007). This implies that each household would save approximately $62.3 per year if effective control of the disease is provided. In contrast, the Vector Control micro-project cost $3 - $4 per person to prevent against potential dengue infection.

Thus, a comparison of the costs involved in the absence of dengue protection ($58 per case for the public sector; $62 per household per year) to this study’s costs per person protected against dengue ($3 - $4 per person) proved that the Vector Control Micro-project was a cost-effective intervention (Table 6).
Recommendation

The analysis of the Vector Control Micro-project recommended the implementation of the intervention as it was highly cost-effective in comparison to other studies against dengue prevention in similar environments and countries ($3 - $4 per person to prevent the disease against $62 per household per year to treat the disease). Several benefits arising from the intervention, though not monetized by this study, were identified:

1. The covering of open water sources in the community added to the positive impacts on the community health as it provided a safer, disease-free environment.

2. Increased awareness about prevention of vector borne diseases through the strong public education and awareness campaign will likely increase the overall standard of living of community residents. The community members are expected to be empowered by the knowledge to protect themselves against potential infection.

3. Protection against potential dengue infection will likely reduce expenses related to hospital visits or hospitalization cases for the community.

4. Protection against potential dengue infection will likely lead to savings in time and money for residents, and could reduce the number of work and school days lost due to illness.
Table 6: Cost Effectiveness Analysis of Vector Control Micro-Project in Antigua and Barbuda

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Proliferation of mosquitoes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope of CEA</td>
<td>Health risk for community members against potential dengue infection</td>
</tr>
<tr>
<td>Communities served</td>
<td>Yorks and Piggotts</td>
</tr>
<tr>
<td>DRR Measure</td>
<td>Vector Control Micro-project includes:</td>
</tr>
<tr>
<td></td>
<td>a. Reducing access of mosquitoes to open stagnant water in households</td>
</tr>
<tr>
<td></td>
<td>b. Elimination of mosquitoes at larval and adult stage using chemical treatment</td>
</tr>
<tr>
<td></td>
<td>c. Strong public education and awareness campaign</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$17,678</td>
</tr>
<tr>
<td>Benefit or Unit of Effectiveness</td>
<td>Number of persons protected against potential dengue infection</td>
</tr>
</tbody>
</table>

COMMUNITY-WISE ANALYSIS

<table>
<thead>
<tr>
<th>Number of residents or number of people protected against dengue infection as result of DRR measure</th>
<th>Yorks</th>
<th>Piggotts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2,145</td>
<td>2,865</td>
</tr>
<tr>
<td>Cost-Effectiveness Ratio or CER (The cost per person of protecting against potential dengue infection)</td>
<td>$4</td>
<td>$3</td>
</tr>
</tbody>
</table>

Section 4: Cost Benefit Analysis (CBA) of Rainwater Harvesting Micro-Project in Suriname

Rainwater Harvesting Micro-projects

Country: Suriname

Name of the Project: Rainwater Harvesting Micro-project

Number of communities (districts) served: Three (Saramacca, Coppename, Commewijne)

INTRODUCTION

Lack of access to clean drinking water and associated health problems were primary concerns of community members in Suriname. The communities in Suriname were very small in size so the Suriname Red Cross (SRC) combined the small-sized communities within the districts of Saramacca, Coppename and Commewijne. This document will continue to refer to these districts as communities in accordance with the practice adopted
by the Red Cross. However, the size of each district is approximately the same as that of a community.

The Rainwater Harvesting Micro-project was proposed for all three communities. The primary hazard and the scope of analysis for all three communities was the same with slight differences. For this reason the rainwater harvesting micro-project analysis is presented in the same section of this document. The micro-project for each community will be presented in different sub-sections.

**MICRO-PROJECT IMPLEMENTATION PROCESS**

Several options for the DRR micro-project emerged from the analysis of results of the KAP surveys, CCCA toolkit, and the VCA process. However, the IFRC deemed many of the suggestions unfeasible and only the proposal for community rainwater harvesting (along with greenhouse farming) was assigned for CBA.

The CBA study was first conducted for Saramacca where rainwater harvesting was proposed as a shared resource for the two communities of Mahodorp and Tottikamp in Saramacca. In the case of Coppename and Commewijne, the FIU-DRR Program strongly recommended the provision of individual rainwater harvesting equipment for each household on the basis of estimates for net benefits. It was reasoned that the DRR intervention would result in an effective improvement in the standard of living for the residents and provide quantifiable net benefits only if it were modified to an ‘individual’ rainwater harvesting micro-project. The modified micro-project would supply rainwater harvesting equipment to each household as opposed to a shared community rainwater harvesting resource in Saramacca. After several efforts to convince the National Society and the project manager to research the costs involved for the modified micro-projects in Coppename and Commewijne, and supporting the modification with the CBA results, individual rainwater harvesting for the two communities was adopted.

In all the rainwater harvesting micro-projects in Saramacca, Coppename, and Commewijne, benefits were calculated using the same assumptions, based on extensive research on case studies and literature.

**Estimation of Benefits:** The benefits gained from rainwater harvesting were calculated using the similar estimates and assumptions for all three communities: Saramacca, Coppename, and Commewijne. This analysis used regional values available for the estimation of benefits for the intervention. Extensive review of published literature was
used to make certain assumptions. Based on standards defined by WHO (2004), the study concluded that both Tottikamp and Mahodorp residents have basic access to water (Pond et al., 2011).

It was estimated that the community members would gain access to improved quality of water at a shorter distance with the intervention. In Saramacca, the distance would be reduced to 150-200m (from 250m) in Tottikamp, and the distance would be reduced to 75m (from .5km) in Mahodorp. For the individual rainwater harvesting micro-projects, it was assumed that the average daily time gained per household by improving the physical access to improved water supply was half an hour (Hutton et al., 2007).

Therefore, the benefits of the microproject estimated in this study from provision of access to clean drinking water were:

a) Improved water quality;

b) Improved access (distance) to water;

c) Saving of time;

d) Reduced incidence of diarrhoeal cases.

For each of the case studies for the CBA of rainwater harvesting in the three Suriname communities, Saramacca, Coppename, and Commewijne, the benefits were calculated thus:

1. Health Benefits:

   a. Direct economic benefits of avoiding diarrhoeal disease in the form of medical costs saved due to less need for treatment of diseases.

      *Direct health benefits of averting disease* were calculated using the annual savings expected in the health sector (Hutton and Haller, 2004), annual savings in patient treatment costs (Hutton and Haller, 2004), and the number of people in the community.

   b. Indirect economic benefit to the community related to health improvement in the form of gain in productive time due to less time being spent ill.

      *Indirect economic benefits related to health improvement* were calculated using the estimated number of diarrhoeal disease avoided per capita per year, number of work days gained per case of diarrhoea avoided, the number of people in the community and the yearly minimum wage.
2. Non-health Benefits:

a. Related to improved water supply in the form of time savings for the household with better access to water. (Time saved with better access).

*Non-health benefits related to improved water service* were calculated using the daily time saved by getting better physical access to water by a household, opportunity cost of the time i.e., the minimum wage per hour and the number of households in the community.

**COMMUNITY: SARAMACCA**

The micro-project for community rainwater harvesting focused on Tottikamp and Mahodorp communities. Tottikamp had approximately 150 – 200 (average 175) residents in approximately 60 households. Their source for drinking water was a river at an average distance of 250 m. The community inhabitants fetched approximately 40 liters of water per trip from the river to their houses. The river water is contaminated, and has increased in salinity because of sea water intrusion. The problem of diarrhea among community residents was very common.

Mahodorp had a population of about 60 elderly people in approximately 18 households. Their source of water was also the river and the creek. Both sources of water are highly contaminated, have increased salinity, and are usually dry during the summer season. Residents of Mahodorp faced acute shortage of water during the summer season during which time they often had to migrate to the nearest town, Paramaribo. Mosquito proliferation was also a significant concern for both the communities.

**THE DRR MICRO-PROJECT: COMMUNITY RAINWATER HARVESTING IN SARAMACCA**

*Objectives*

The objective of the community rainwater harvesting micro-project was to provide improved access to clean drinking water through common rainwater harvesting sources to the community residents of Mahodorp and Tottikamp. The provision of clean and safe drinking water was expected to provide direct and indirect health benefits from reduced incidents of diarrhoeal infections, and significantly reduce the time spent in collecting water every day.

The SRC set up two water harvesting plants, one in Tottikamp and one in Mahodorp, in the central part of each community. Eight rainwater collecting tanks were set up in Tottikamp and four in Mahodorp. Each tank had a storage capacity for 450 gallons or 1700 liters. The
water collected from harvesting was strictly meant for drinking purpose alone. Disinfecting service was not provided. However, community members were educated about the basic methods of disinfecting the water. Mosquito nets were also distributed in both the villages to combat the problem of mosquitoes.

COST BENEFIT ANALYSIS OF THE COMMUNITY RAINWATER HARVESTING MICRO-PROJECT IN SARAMACCA

Study Parameters

The primary concern of the community residents was shortage of clean and safe drinking water along with mosquito proliferation and diarrhoeal infection. This study focused on the same concern and identified the direct and indirect health, and non-health benefits associated with the low cost provision of improved access to clean drinking water.

Data Collection

The information on costs for the rainwater harvesting equipment, labor, and construction of the shared resource was provided by the SRC project manager and staff. The estimates for benefits were based on intensive research on case studies and associated literature.
Estimation of Costs and Benefits

Costs: The sum of investment costs, administrative salaries, and labor costs was 17,650 USD (provided by the Suriname Red Cross project manager). Opportunity costs were not provided for the micro-project. No maintenance costs were reported.

Benefits: The sum of direct health benefits of averting disease, indirect economic benefits related to health improvement, and non-health benefits related to improved access to water service were estimated for both villages in Saramacca. Based on this study’s estimate, Saramacca residents would gain $37,000 per year as a result of improved access of water supply provided by the SRC through its community rain water harvesting project (Table 7).

Cost Benefit Analysis

The project life of the community rainwater harvesting intervention was assumed to be 5 years. A cost benefit analysis, using a 5 year lifetime for the project, and using a discount rate of 3.91% (http://www.tradingeconomics.com/suriname/real-interest-rate-percent-wb-data.html), yielded a Benefit Cost Ratio (BCR) of 7.63. The net benefit of the project in present value terms was $116,943 (Table 7).

Sensitivity Analysis

The discount rate used for the analysis was based on Suriname’s Central Bank rate (3.91%). This discount rate was tested and compared to alternate values of 5%, 7%, and 10%. The sensitivity analysis yields a range of BCRs from 7.63 (discount ratio: 3.91%) to 6.65 (discount ratio: 10%) (Table 8).

Recommendation

The benefit cost ratio of 7.6 for the community rainwater harvesting micro-project in Saramacca indicates that the benefits of provision of improved access to clean drinking water to the community are high. The micro-project would lead to several positive impacts to the community including health and non-health related benefits. In five years’ time the present value of the net returns for the investment will be $116,943.

The benefits of community members not needing to walk far to get access to clean drinking water cannot be captured by monetary values alone. The rise in standard and comfort of living to the community members is not indicated in the BCR alone. Similarly, the benefits of gaining better health, and community members not suffering from frequent cases of diarrhoea, though represented by the BCR, represent a much higher value to the beneficiaries and are difficult to quantify.
COMMUNITY: COPPENAME

Kalebaskreek is an indigenous village along the Coppenname River and a boat takes about 30 – 45 minutes from Boskamp to reach the community. The community of approximately 200 residents faced acute challenges regarding water supply during the year. In the rainy season, crops were often lost because of flooding, the village being surrounded by swamp and the river. In the dry season, the community suffered from drinking water shortage because of a dysfunctional water distribution system. In addition, the community people did not have the proper capacity to store water safely for a longer period. The village has a small school, with a new one under construction. No government facilities are present. For emergency healthcare, residents have to go by river to reach Boskamp where they catch a taxi to go further down to a small town called Calcutta.

THE DRR MICRO-PROJECT: INDIVIDUAL RAINWATER HARVESTING MICRO-PROJECT IN COPPENAME

This intervention was modified from a community rainwater harvesting micro-project to an individual one in the cost benefit analysis phase of the study. The FIU-DRR Program strongly advised the modification as it made the intervention far more effective in delivering positive impacts to the community members over and above the benefits received by a community rainwater harvesting micro-project.

Objectives

The objective of the individual rainwater harvesting micro-project was to provide improved access to clean drinking water by installing rainwater harvesting capacities in each household. Disinfecting service was not provided. Community members were educated about the basic methods of disinfecting the water. This study identified the direct and indirect health, and non-health benefits associated with the low cost provision of improved access to clean drinking water.

COST BENEFIT ANALYSIS OF INDIVIDUAL RAINWATER HARVESTING MICRO-PROJECT IN COPPENAME

Study parameters

The primary concern of the community residents was shortage of clean and safe drinking water along with mosquito proliferation and diarrhoeal infection. This study will focus its analysis on the problem of access to clean drinking water, and potential diarrhoeal infection arising from contaminated water. The study identified the health and non-health benefits associated with the low cost provision of improved access to clean drinking water to each
Data Collection

The information on costs for the rainwater harvesting equipment, labor and construction of the shared resource was provided by the Suriname Red Cross project manager and staff. The estimates for benefits were based on intensive research on case studies and associated literature.

Estimation of Costs and Benefits

Costs: The sum of all financial costs including costs for education and awareness were 19,158 USD (Suriname Red Cross project manager). No maintenance costs were reported.

Benefits: The sum of direct health benefits of averting disease, indirect economic benefits related to health improvement, and non-health benefits related to improved access to water service were estimated for Coppename. Based on this study’s estimate, Coppename residents would gain $30,255 per year as a result of improved access of water supply provided by the SRC through its community rain water harvesting project (Table 7).

Cost Benefit Analysis

A cost benefit analysis, using a 10 year lifetime for the individual rainwater harvesting micro-project, and a discount rate of 3.91% (http://www.tradingeconomics.com/suriname/real-interest-rate-percent-wb-data.html), yielded a Benefit Cost Ratio (BCR) of 11.79. The net benefit of the project in present value terms over the next ten years was estimated at $206,723 (Table 7).

Sensitivity Analysis

The discount rate used for the analysis was based on Suriname’s Central Bank rate (3.91%). This discount rate was tested and compared to alternate values of 5%, 7%, and 10%. The sensitivity analysis yields a range of BCRs from 11.79 (discount ratio: 3.91%) to 9.09 (discount ratio: 10%) (Table 8).

Recommendations

The individual rainwater harvesting micro-project was highly recommended as it yielded a BCR of 11.79 and an NPV of $206,723 over a ten year period.

The individual rainwater harvesting intervention provided benefits over and above the
community intervention with access to clean and safe water to individual households. Residents no longer had to fetch water from a distance and this could dramatically alter the comfort levels and the standard of living of the community residents. The risk of potential diarrhoeal infection arising from contaminated water was expected to reduce and thus lead to the improvement of the overall community health.

COMMUNITY: COMMEWIJNE

Kroonenburg is a small coastal community surrounded by the sea and a river. The only way to reach the community of 79 households is by boat after a 45 minutes road trip from the capital. The main problems for this almost isolated community were lack of potable water and intrusion of sea water. The main economic activities of this community are agriculture and fishery. Since water was the main concern in this community, the FIU-DRR program advised an individual rainwater harvesting project as the one as in Coppename as opposed to a community-shared rainwater harvesting project. This involved provision of the necessary infrastructure to collect drinking water for each household in the community. Some houses had proper infrastructure to collect the rain water whereas others need improvement. Awareness on health issues and maintenance were part of the micro-project’s objectives.

THE DRR MICRO-PROJECT: INDIVIDUAL RAINWATER HARVESTING MICRO-PROJECT FOR COMMEWIJNE

Objectives

The objective of the individual rainwater harvesting micro-project was to provide improved access to clean drinking water by installing rainwater harvesting capacities in each household. This study identified the direct and indirect health, and non-health benefits associated with the low cost provision of improved access to clean drinking water. The estimation of benefits yielded different results from those in Coppename because of the difference in the number of beneficiaries in each community.

Costs: The sum of all financial costs including costs for education and awareness were 19,158 USD (SRC project manager). No maintenance costs were reported.

Benefits: The sum of direct health benefits of averting disease, indirect economic benefits related to health improvement, and non-health benefits related to improved access to water service were estimated for Commewijne. Based on this study’s estimate, Commewijne residents would gain $59,754 per year as a result of improved access of water supply provided by the SRC through its community rain water harvesting project (Table 7).
Cost Benefit Analysis

In total, community residents of Kroonenburg were expected to gain $59,754 per year as a result of improved access to clean drinking water supply provided by the Suriname Red Cross through its individual rain water harvesting micro-project for each household.

A cost benefit analysis, using a 10 year lifetime for the individual rainwater harvesting project, and using a discount rate of 3.91% (http://www.tradingeconomics.com/suriname/real-interest-rate-percent-wb-data.html), yielded a Benefit Cost Ratio (BCR) of 22.32. The net benefit of the project in present value terms over the next ten years was estimated at $426,133 (Table 7).

Sensitivity Analysis

The discount rate used for the analysis was based on Suriname’s Central Bank rate (3.91%). This discount rate was tested and compared to alternate values of 5%, 7%, and 10%. The sensitivity analysis yields a range of BCRs from 22.32 (discount ratio: 3.91%) to 17.22 (discount ratio: 10%) (Table 8).

Recommendations

The individual rainwater harvesting micro-project was highly recommended as it yielded a high BCR of approximately 22.32 and a net present value of over $426,133 over a ten year period. The benefits are higher for Commewijne than in Coppenname as the micro-project benefits more people (395 as opposed to 200).

The individual rainwater harvesting intervention provides benefits over and above a community intervention as it provides access to clean and safe water to each household individually. Residents no longer have to fetch water from a distance and this can dramatically alter the comfort levels and the standard of living of the community residents. The risk of potential diarrhoeal infection arising from contaminated water is highly reduced and thus improved the overall community health.
Table 7: CBA of Rainwater Harvesting Micro-projects in Suriname communities

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Lack of access to clean drinking water, frequent diarrhoeal infections, mosquito proliferation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope of Study</td>
<td>The CBA will focus on lack of access to clean drinking water and health risk to community from contaminated water.</td>
</tr>
<tr>
<td>Communities</td>
<td>Saramacca</td>
</tr>
<tr>
<td></td>
<td>Tottikamp</td>
</tr>
<tr>
<td>Number of people served</td>
<td>175</td>
</tr>
<tr>
<td>Costs</td>
<td>$17,650</td>
</tr>
</tbody>
</table>

Benefits

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Direct Health Benefits from averting disease</th>
<th>Indirect Economic Benefits from heath improvement</th>
<th>Non-Health Benefits related to time savings</th>
<th>Total Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saramacca*</td>
<td>$945</td>
<td>$15,372</td>
<td>$11,607</td>
<td>$37,000</td>
</tr>
<tr>
<td>Coppename**</td>
<td>$324</td>
<td>$5,270</td>
<td>$3,482</td>
<td>$30,255</td>
</tr>
<tr>
<td>Commewijne**</td>
<td>$1,080</td>
<td>$17,568</td>
<td>$11,607</td>
<td>$59,754</td>
</tr>
<tr>
<td>CBA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project lifetime</td>
<td>5 years</td>
<td>10 years</td>
<td>10 years</td>
<td></td>
</tr>
<tr>
<td>Discount Rate</td>
<td>3.91%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCR</td>
<td>7.63</td>
<td>11.79</td>
<td>22.32</td>
<td></td>
</tr>
<tr>
<td>NPV</td>
<td>$116,943</td>
<td>$206,723</td>
<td>$426,133</td>
<td></td>
</tr>
</tbody>
</table>

Table 8: Sensitivity Analysis: Variation in BCR with different discount rates – Rainwater Harvesting Micro-projects in Suriname communities

<table>
<thead>
<tr>
<th>Discount Ratio</th>
<th>3.91%</th>
<th>5%</th>
<th>7%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saramacca*</td>
<td>7.63</td>
<td>7.43</td>
<td>7.1</td>
<td>6.65</td>
</tr>
<tr>
<td>Coppename**</td>
<td>11.79</td>
<td>11.22</td>
<td>10.29</td>
<td>9.09</td>
</tr>
<tr>
<td>Commewijne**</td>
<td>22.32</td>
<td>21.25</td>
<td>19.48</td>
<td>17.22</td>
</tr>
</tbody>
</table>

*Community Rainwater harvesting, time horizon 5 years; ** Individual Rainwater Harvesting, time horizon: 10 years.
Section 5: Cost Benefit Analysis (CBA) of Greenhouse Farming Micro-Project in Suriname

Greenhouse Farming Micro-project

Country: Suriname

Name of the Project: Greenhouse Farming Micro-project

Number of communities (districts) served: One: Coronie

INTRODUCTION

Coronie, a district in the coastal area of Suriname, is mainly a farming community. The Greenhouse Farming micro-project implemented by the Suriname Red Cross (SRC) under the Red Cross Project benefitted the villages of Totness, Ingikondre, and Burnside.

Salt water intrusion caused by sea level rise is one of the biggest challenges facing the farming community of Coronie. In addition, the damaged sluice gates along the sea wall have caused sea water intrusion into the swamps leading to considerable loss of vegetation and biodiversity in this area.

The cultivation of different vegetables in the district of Coronie is mostly done using rain-fed techniques. As such the farmers’ income is subject to seasonal fluctuations in production and market price. The effects are clearly visible in Coronie where one of the micro-projects on greenhouse farming is being implemented. Changes in the weather patterns as a result of climate change have made it a lot more difficult for farmers to plan and produce good quality produce in sufficient quantity for the market in Coronie or for the closest market in Nickerie.

MICRO-PROJECT IMPLEMENTATION PROCESS

The process of the selection of the greenhouse farming micro-project and its implementation followed the IFRC plan described in Chapter 2 (see Figure 2) with some deviations. Coronie was identified as a community of concern for the Red Cross Project through the Community Selection Tool (CST). Baseline KAP surveys along with the CCCA toolkit established that the farming community was facing loss in income because of decrease in agricultural production. Saltwater intrusion, shortage of water supply, and changes in weather patterns were identified as the primary hazards. Greenhouse farming was proposed as one of the possible options and was assigned for CBA by the IFRC. Other options were rejected for being unfeasible because of costs as well as concerns about compliance with regulations. Upon receiving the results of the CBA, the micro-project was implemented. This was followed by the endline surveys.
THE DRR MICRO-PROJECT: GREENHOUSE FARMING MICRO-PROJECT

Greenhouse cultivation can help minimize several problems that conventional open cultivation in coastal Suriname faces because of climate change and salt water intrusion. The technique of greenhouse farming can be used to minimize the seasonal fluctuation in crop yields and help farmers achieve consistent good quality production. Greenhouse farming is an intensive farming method in terms of yield, annual production and investment (Taki et al., 2012). It is estimated that farmers will be able to grow desired crops throughout the year and avoid the inhospitable agro-climatic conditions (Sengar and Kothari, 2008). However, the initial investment for construction of greenhouses and production is a significant constraint for farmers. The Greenhouse Farming Micro-project’s aim was to assist the Coronie farming community in overcoming this initial hurdle by constructing three greenhouses in the community.

Objectives

The Greenhouse Farming micro-project collaborated with Inter-American Institute for Cooperation on Agriculture (IICA) to manage and operate the greenhouses, employing nine community farmers, for the first year of the project. The greenhouses in the micro-project were designed to serve as a model that could be adopted and replicated by the rest of the Coronie farming community. It was expected that the micro-project would improve the economic conditions of the nine farmers engaged during the one year micro-project in the three greenhouses thereby providing a boost to the local agricultural enterprise.

Successful introduction of greenhouse techniques in rural areas must include the use of locally available material for construction of greenhouses. The district of Coronie had plenty of bamboo available. Bamboo has been used in many places as building material for greenhouses. Without the use of preservatives, bamboo, like almost any wood, has a high chance of being attacked by insects. Bamboo insect infestation occurs due to the presence of starch and other carbohydrates. Mold and fungus originate from very fine, air-borne spores present in fruit bodies and cause biological degradation of bamboo. For this micro-project, the bamboo was treated with borax, a harmless chemical that makes the bamboo last up to ten years.

The specific objectives of the micro-project were:

1. Build three bamboo greenhouses
2. Construct irrigation systems for all greenhouses
3. Provide additional water systems for all greenhouses

4. Provide training in greenhouse construction and production to the nine farmers.

**COST BENEFIT ANALYSIS OF THE GREENHOUSE FARMING MICRO-PROJECT IN CORONIE**

*Study Parameters*

The primary hazards identified by the community were salt water intrusion, shortage of fresh water and changing weather patterns. The farming community had experienced declining agricultural outputs in the last few years followed by lowered income. This study will focus its analysis on the lowered agricultural production of the farming community because of climate change impacts.

*Data Collection*

Information on costs was obtained by the Suriname Red Cross project manager. Consultation with experts from the Inter-American Institute for Cooperation on Agriculture (IICA) provided the information on costs for constructing and maintaining the greenhouses and the expected agricultural production and its market value. Literature review was an important source of information and estimates.

*Estimation of Costs and Benefits*

**Costs:** The costs of the initial construction, year round inputs and activities have been provided by IICA. The construction costs for all three greenhouses including the cost of agricultural inputs like seeds and fertilizers every year and water inputs, and transportation were estimated at $18,581 for the first year of the micro-project.

**Benefits:** The benefits of the project were estimated as the increase in the income of the farmers from improved agricultural production with the use of the intensive greenhouse farming method. The study assumed that the farmers in Coronie were earning minimum wages prior to the micro-project as reliable data on their agricultural income prior to this project was unavailable. The minimum wage in Suriname was 600SRD per month (http://www.state.gov/j/drl/rls/hrrpt/humanrightsreport/index.htm#wrapper and http://www.minimum-wage.org/international/en/Suriname) or USD 2,196 per year (http://www.xe.com/currencyconverter/convert/?Amount=1&From=USD&To=SRD).
Chapter 4

The market value of the goods produced by the three greenhouses was expected to be approximately $33,511 per year (estimates by experts at IICA).

Cost Benefit Analysis

The project life was assumed to be 10 years. The discount rate used was 3.91% (http://www.tradingeconomics.com/suriname/real-interest-rate-percent-wb-data.html).

The net present value or gains from the greenhouse farming project in Coronie was $50,948. The BCR for the project was calculated to be 2.6.

Sensitivity Analysis

The discount rate used for the analysis was based on Suriname’s Central Bank rate (3.91%). This discount rate was tested and compared to alternate values of 5%, 7%, and 10%. The sensitivity analysis yields a range of BCRs from 2.60 (discount ratio: 3.91%) to 2.06 (discount ratio: 10%) (Table 8).

Recommendations

The micro-project was recommended for implementation as the BCR was 2.6, the profits outweighed the costs. The NPV of the ten year micro-project was $50,948 making the micro-project a sound investment.

There are several qualitative benefits that greenhouse farming is expected to yield. Besides providing income from agricultural activity, the micro-project serves as a model for the community. Other farmers are expected to learn the technique and adopt the practice themselves upon observing the success of the nine farmers involved in the micro-project. Education of the farming community on climate change impacts, sea level rise, and salt water intrusion will be considered a significant step in the gradual process of climate change adaptation. It is expected that the intervention will raise the standard of living of several community households involved.
Table 9: Cost Benefit Analysis of Greenhouse Farming Micro-project in Coronie, Suriname

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Salt water intrusion in water bodies and soil, shortage of water supply, changing weather patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope of Study</td>
<td>Study will analyze decrease in agricultural yield of farming community</td>
</tr>
<tr>
<td>Communities served</td>
<td>Coronie (Ingiekondre, Totness, Burnside)</td>
</tr>
<tr>
<td>DRR Measure</td>
<td>Greenhouse farming micro-project will: - Build 3 model greenhouses - Provide irrigation supply the greenhouses - Train 9 farmers for the micro-project</td>
</tr>
<tr>
<td>Costs</td>
<td>$18,581</td>
</tr>
<tr>
<td>Benefits</td>
<td></td>
</tr>
<tr>
<td>Quantitative Benefits</td>
<td></td>
</tr>
<tr>
<td>Value of Production from all three GH in 1st year</td>
<td>$33,511</td>
</tr>
<tr>
<td>Yearly income of 9 farmers (based on minimum wage)</td>
<td>$19,764</td>
</tr>
<tr>
<td>Net Quantitative Benefits per year</td>
<td>$13,747</td>
</tr>
<tr>
<td>Qualitative Benefits</td>
<td>Other farmers learn the process by observation, adapt technique Raises the standard of living of households engaged in the activity Education on climate change, sea level rise, and salt water intrusion is part of climate change adaptation process</td>
</tr>
<tr>
<td>CBA</td>
<td></td>
</tr>
<tr>
<td>Lifetime of micro-project</td>
<td>10 years</td>
</tr>
<tr>
<td>Discount Rate</td>
<td>3.91%</td>
</tr>
<tr>
<td>BCR</td>
<td>2.6</td>
</tr>
<tr>
<td>NPV</td>
<td>$50,948</td>
</tr>
</tbody>
</table>

Table 10: Sensitivity Analysis: Variation in BCR with different discount rates – Greenhouse Farming Micro-project in Coronie

<table>
<thead>
<tr>
<th>Discount Ratio</th>
<th>3.91%</th>
<th>5%</th>
<th>7%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse Farming Micro-project, Coronie</td>
<td>2.60</td>
<td>2.49</td>
<td>2.31</td>
<td>2.06</td>
</tr>
</tbody>
</table>
Chapter 5: Key Findings and Discussion of Results

The key findings and results of the economic analysis of the Red Cross Project’s community-based DRR micro-projects in the Caribbean region can be best understood in the context of the environment in which the micro-projects were implemented.

PROJECT SET-UP

The Red Cross Project began in March 2012 but it took a long time for all the pieces to fall into place and the implementation to begin. Administrative hiccups in laying the groundwork for implementation, hiring of professionals to fill key positions, and in defining of activities within the pilot phase of the Red Cross Project did not make the process smooth. The impacts of Hurricane Sandy added to the delays in the initial period of the pilot phase in Jamaica. The baseline surveys (KAP, CCCA toolkit, and JHU tool) were long-winded and tedious for the interviewer as well as interviewee. Community members found some questions regarding personal hygiene and sanitation to be highly intrusive that they refused to answer. By the time the deadline for the pilot phase of the Red Cross Project neared, the options for micro-projects had to be hastily assigned for CBA and then implemented.

MICRO-PROJECT IMPLEMENTATION PROCESS

The process of micro-project implementation was planned by the IFRC in such a way that community members would collectively choose a DRR micro-project for implementation in their community to address the primary hazard in the most cost-effective manner. The implementation process required much deliberation on the part of the community members with assistance from project managers and field officers. The CBA was an integral part of the decision-making process (Figure 1).
However, as events played out, the delays in the earlier part of the Red Cross Project also set back the initiation of micro-project implementation. The project cycle became long drawn-out. A consequence of this was that the different micro-projects deviated from the steps outlined in the process of micro-project implementation. In most cases, the community did not decide on micro-project alternatives. For each community, a proposal for a micro-project emerged as an outcome of the baseline survey process or as suggested by project managers or key stakeholders in the community. This proposal was directly assigned to the FIU-DRR Program for development of CBA methodologies. Upon developing a specially designed methodology for each DRR intervention, the FIU-DRR Program trained the project managers in CBA application. The project managers were expected to apply the CBA methodology for each DRR intervention thereafter. However, except for the Diamond Hole Restoration Micro-project in Antigua, the FIU-DRR Program conducted the application of the CBA methodologies for all the DRR interventions. The DRR micro-projects were then implemented. The results of the CBA were not shared with community members.

Thus, the core components of the micro-project implementation process: collective and collaborative decision-making, and integration of CBA with the decision-making at the level of community members as well as that of project managers remained unfulfilled.

**RESULTS OF THE ECONOMIC ANALYSIS – COST BENEFIT ANALYSIS AND COST-EFFECTIVENESS ANALYSIS**

The results of the CBAs and the CEA of the DRR interventions implemented in the Caribbean region in the pilot phase of the RC project are summarized in Table 11.

*Benefit Cost Ratio (BCR) and Net Present Value (NPV)*

The Benefit Cost Ratio is the indicator of economic efficiency of a cost benefit analysis. It is calculated as the ratio of discounted benefits to discounted costs of an intervention. Similarly, the Cost-Effectiveness Ratio or CER is the indicator of economic efficiency of a cost-effectiveness analysis. The NPV is an indicator of the discounted benefits above the costs through the entire (assumed) lifetime of the project. These values for the BCRs, CER, and NPVs of the CBAs and CEA of the different DRR interventions for the Red Cross Project are given in Table 11.
Table 11: Summary of FIU-DRR Program’s Economic Analysis of DRR micro-projects in the Red Cross (RC) Project, Increasing Climate Change Resilience in Caribbean Communities, in three Caribbean Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Jamaica</th>
<th>Antigua &amp; Barbuda</th>
<th>Suriname</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of DRR project</td>
<td>Safer Shelters Component*</td>
<td>Diamond Hole</td>
<td>Community RWH</td>
</tr>
<tr>
<td>DRR Intervention</td>
<td>Home Retrofitting and Rebuilding</td>
<td>Restoration of malfunctioning dam</td>
<td>Community shared rainwater harvesting source</td>
</tr>
<tr>
<td></td>
<td>Restoration of malfunctioning dam</td>
<td>Targeting mosquito proliferation</td>
<td>Provision of rainwater harvesting source for each household</td>
</tr>
<tr>
<td></td>
<td>Restoration of malfunctioning dam</td>
<td>Targeting mosquito proliferation</td>
<td>Provision of rainwater harvesting source for each household</td>
</tr>
<tr>
<td>Number of communities served</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Name of communities</td>
<td>Windsor, Prospect, Flint River, Gully Road, Killancholly</td>
<td>Bendals</td>
<td>Saramacca</td>
</tr>
<tr>
<td>Type of economic analysis</td>
<td>CBA</td>
<td>CEA</td>
<td>CBA</td>
</tr>
<tr>
<td>DR used</td>
<td>2%</td>
<td>6.50%</td>
<td>3.91%</td>
</tr>
<tr>
<td></td>
<td>$17,678</td>
<td>$17,650</td>
<td>Number of people protected against potential dengue infection</td>
</tr>
<tr>
<td>Benefits (Quantified)</td>
<td>Avoided loss from windstorm damage to houses</td>
<td>Increase in agricultural production and household water supply</td>
<td>Health (Direct and indirect) and Non-Health (Time saved) Benefits</td>
</tr>
<tr>
<td>BCR (Financial/Social)</td>
<td>Home Retrofit: 1.15/1.02 Home Rebuilding: 0.16/0.15</td>
<td>215/112</td>
<td>CER, Yorks - $4/person protected CER, Piggotts - $3/person protected</td>
</tr>
<tr>
<td></td>
<td>7.63</td>
<td>Coppenname: 11.79; Commewijne: 22.32</td>
<td>2.6</td>
</tr>
<tr>
<td>NPV (Financial/Social)</td>
<td>Home Retrofit: $5,544,577/</td>
<td>$5,793,679</td>
<td>Coppenname: $206,723</td>
</tr>
<tr>
<td></td>
<td>$116,943</td>
<td>Commewijne: $426,133</td>
<td>$50,948</td>
</tr>
<tr>
<td>Number of Beneficiaries</td>
<td>Home Retrofit: 76 households Home Rebuilding: 6 households</td>
<td>Information not available</td>
<td>Yorks: 2,145 Piggotts: 2,865</td>
</tr>
<tr>
<td></td>
<td>235</td>
<td>200</td>
<td>395</td>
</tr>
<tr>
<td>Number of people served/reached</td>
<td>2,454</td>
<td>2,784</td>
<td>830</td>
</tr>
</tbody>
</table>

*Safer Shelters Component was the Jamaican chapter of Output 1 and not a micro-project*
The donor agency had set the precondition for BCR equal to 2 for each micro-project before granting approval for implementation. All micro-projects obtained BCR values higher than 2 and were implemented. The Safer Shelters Component in Jamaica was the only intervention that did not meet the standard set by DFID. The financial BCRs of the home retrofitting (1.15) and home rebuilding (0.16) elements of the Safer Shelters Component were lower in comparison. In the case of home retrofitting, the financial costs were just equal to the expected benefits and were much higher than the benefits from home rebuilding. As the home retrofitting and rebuilding component Red Cross Project was already underway when the CBA results were estimated, the Jamaican chapter of Output 2 continued to be implemented.

The project had low net returns (Financial NPV $7,304) for the home retrofitting and the value was negative for the home rebuilding (-$69,906). On adding the social opportunity costs, the BCR and NPV values were even lower. The values obtained for BCR and NPV of the Safer Shelters Component can be explained as follows:

1. The Safer Shelters Component was a substantial part of the Red Cross Project’s pilot phase with high investment costs. Investment costs are generally high for any pilot phase of a project as it lays the groundwork for the subsequent phases of the Red Cross Project in Jamaica.

2. The challenge for the cost benefit analysis of this Component was in capturing the benefits arising out of the home retrofitting and rebuilding. Site specific data on the hazard assessment (windstorm) and impact assessment (windstorm damage) was not available. In addition, a bigger hindrance for the analysis was the lack of technical specifications and building codes for home retrofitting and rebuilding followed by the Safer House Methodology. This did not allow the CBA to attach reliable levels of protection to the homes retrofitted or rebuilt which ultimately weakened the BCR as well as the NPV.

3. It was also necessary to keep in mind the qualitative benefits that were likely to be achieved through this intervention. The increase in the standard of living for the families in the improved houses, the avoided loss of physical property, and the unquantifiable benefit of living in a safer home are not captured by the BCR and NPV of the Safer Shelters Component.

4. The strong impacts of public education and awareness among the community members through the Safer Shelters Component were not reflected in the BCR and NPV of the analysis.
The highest BCR and NPV (financial and social) values were obtained in the Diamond Hole Dam Restoration Micro-project in Bendals. This micro-project increased the irrigation supply to several farms in the community which was expected to lead to a high increase in the income derived from agricultural outputs. The market value of the expected agricultural outputs from an extra growing season added to the year along with a longer projected lifetime of the micro-project were responsible for the expected handsome net returns of the micro-project.

*Expected Qualitative Impacts of the DRR interventions in the Pilot Phase of the RC Project*

1. Economic impacts: The communities selected for the all the DRR interventions were economically vulnerable. It was expected that the different DRR interventions will have positive economic impacts for all communities.

   In Jamaica, home owners will likely experience an increase in the market values of their homes that have been retrofitted or rebuilt by the Safer Shelters Component. With a higher level of protection against windstorms, a reduction in the vulnerability of community members from losing their homes or in preserving their moveable property was expected.

   In Antigua, the Diamond Hole Dam Restoration micro-project was expected to raise the income of farm owners and provide more employment to farm workers through the micro-project. The Diamond Hole Restoration by increasing the holding capacity of the dam reservoir was expected to reduce the damage to homes and moveable properties of residents in Bendals and other neighboring communities.

   In Suriname, the Greenhouse Farming micro-project was expected to result in higher income for the families involved and offer better economic prospects to the rest of the farming community coping with palpable climate change impacts on their source of income. Improved access to clean drinking water in the Suriname communities will raise the standard of living for the residents with tangible though indirect economic savings from avoided medical expenses and time saved.

2. Social impacts: Several positive impacts of the DRR interventions are anticipated:


   b. Increase in education and awareness of community members on disaster risk reduction and health risk reduction as relevant to their communities, climate change impacts and disease prevention measures. Increase in awareness about
issues of concern was expected to lead to empowerment of the community members.

c. Increase in community organization and engagement through regular meetings under the Red Cross Project on DRR issues relevant to each community. Community members were expected to enhance relationships with each other by discussing common problems and working toward solutions. They would build relationship with key stakeholders and government officials as they attended meetings together.

d. Training of youth as volunteers for baseline and endline surveys increased their engagement with the community while giving them gainful employment.

e. Special skills were imparted to certain community members in home retrofitting and rebuilding, in the Safer Shelters Component, who then were expected to pass on their knowledge and skills to other residents. This would create a ripple effect as the rest of the community would be motivated to increase the level of protection in their houses against potential windstorm damage.

3. Environmental impacts: Although this study did not research any impacts of the DRR interventions on the ecosystem, some positive environmental impacts are expected to arise in the long-term. The restoration of the Diamond Hole Dam was expected to reduce flooding and soil erosion in the community that would increase soil fertility and lead to conservation of soil in the long-term. The Vector Control micro-project was expected to result in a safer, disease-free environment for the community. The Greenhouse Farming micro-project promoted the transition of the farming community to better adapt to the changing climatic conditions. As affected communities are expected to move from mitigation to adaptation activities with respect to climate change impacts, this DRR intervention will likely provide the necessary capacity to the farmers while empowering the community.

**Complexity of the Analysis**

The economic analysis of the five types of DRR interventions implemented in the pilot phase of the Red Cross Project – the Safer Shelters Component in Jamaica, the Diamond Hole Dam Restoration, Vector Control, Rainwater Harvesting, and the Greenhouse Farming micro-projects – ranged from simple to complex depending on the availability of data. Attempts were made to maintain a simplified approach to the analysis without sacrificing the technical criteria necessary to maintain the integrity of the exercise.
The analysis for the Vector Control micro-project was done using the simplified approach of cost-effectiveness analysis. In the Greenhouse Farming micro-project in Suriname, the classic approach of CBA was used to calculate the net benefits in income from agricultural by comparing the before and after scenario. The same was done for the Diamond Hole Dam Restoration micro-project in Antigua and Barbuda.

The analysis for the Safer Shelters Component was the most challenging because of limited data availability and the lack of technical specifications or regulatory codes for the home retrofitting and rebuilding in the vulnerable communities.

The most complicated analysis was that for the Rainwater Harvesting micro-project where the analysis captured a) direct health benefits, b) indirect benefits from health improvement, and c) non-health benefits from time savings with improved access to water supply. All these benefits were expected to arise from improved access to clean drinking water supply through rainwater harvesting.
Chapter 6: Recommendations

This report presented the case studies on cost benefit analyses and cost-effectiveness analysis of community-based DRR interventions in the Caribbean. The DRR interventions were part of the pilot phase of the Red Cross Project, *Improving Climate Change Resilience of Caribbean Communities*. The interventions, mostly in the form of micro-projects, except Safer Shelters, targeted natural disaster risks, health risks, and climate change impacts in three Caribbean countries – Antigua & Barbuda, Jamaica, and Suriname. The CBA and CEA of community-based DRR interventions provided effective, evidence-based tools to estimate the economic efficiency of the proposed DRR interventions.

All the DRR interventions analyzed obtained a BCR above 1 (including the financial BCR of home retrofitting in the Safer Shelters Component), justifying the implementation of all the interventions. For interventions other than Safer Shelters, the BCR ranged from 2.6 to 215. These values not only justified the micro-projects but made a strong case for implementation in the vulnerable Caribbean communities. In addition, the estimation of benefits for all studies was conservative and based on extensive literature review.

It would be unfair to judge any of the DRR interventions in the pilot phase without including the non-monetized, qualitative impacts that were expected to arise from the increase in community awareness and education, the increase in the level of engagement of the communities in decision-making and implementation, improved standard of living through economic means or otherwise, and improved access to clean drinking water.

The economic analysis for the pilot phase of the Red Cross Project revealed several areas for consideration for such analyses in the future.
1. The delays observed in the implementation of the Safer Shelters Component and the DRR micro-projects in the pilot phase of the Red Cross Project were indicative of the deviation from the adherence to the elements of a typical project life cycle. The administrative delays mentioned in Chapter 5 precluded the timely execution of the latter part of the pilot phase. The most important recommendation that arises from this experience is that the project personnel at the National Society level should be trained in and sensitized to the various steps in project cycle management.

2. The integration of economic analysis in the form of CBA and CEA with project cycle management in DRR projects is highly recommended. Economic analysis must be incorporated at the stage of project identification, appraisal, as well as analysis. Again, this can be achieved only if the steps in project cycle management are followed and project managers are trained in CBA methodology and application.

3. It is strongly advised that the training in economic analysis of DRR interventions for project managers and field officers take place at the initial phases of the project cycle. Equipped with the knowledge and the rationale behind CBA for DRR interventions, they could not only become willing participants of the process but become competent practitioners in the field itself. However, the training should be followed by close monitoring and evaluation along with technical support.

4. A cost benefit analysis relies heavily on the site specific data on hazard and impact assessments. It requires project managers and field officers to become efficient in data collection, record keeping, and become familiar with the sources of necessary site specific information on hazards and their impacts. This, too, implies the need for comprehensive training in CBA in the initial phases of a DRR project.

5. The mainstay of the DRR micro-project implementation process (as initially planned, see Figure 1) was that it would encourage high level of community engagement in every step of decision-making. The implied goals of the advised process were that the community would become familiar with the basic concepts of CBA with assistance from project managers and field officers. However, the planned process was soon discarded or circumvented in light of the initial delays in the Red Cross Project and for reasons of constraints in time and resources. Moreover, the concept of CBA was not introduced to community members, defeating the purpose of the initial implementation process. Thus, the community’s role in decision-making was restricted.
6. It would be highly advisable that economic analysis of community-based DRR interventions be simplified for field officers for easy implementation. The analyses could also be developed as a template that automatically generates CBA results when data is fed into it. At the same time, applications for CBA cannot be made in one size that fits all. Trained project managers will have to tailor the methodology according to the needs of a particular case.

7. Cost effectiveness analysis is an easier concept to grasp and implement. CEA must be emphasized and encouraged in training and practice.

8. The Geoscience and Technology Division (SOPAC) of the Secretariat of the Pacific Community (SPC) has used Least Cost Analysis as a precursor to CBA for various projects. Least cost analysis gives an estimate of the flow of costs overtime and ranks project options on the basis of their costs. This practice may help project managers to identify suitable project options and keep costs under consideration.

9. It is recommended that the capacity for building informational sources that provide site specific data on hazards and their impacts be available to project managers so that better decisions can be made using CBA.

10. This CBA study relied heavily on estimations and assumptions based on limited data and extensive literature review. Improvement in informational support from the National Societies will be necessary to refine the cost benefit analyses.


International Federation of Red Cross and Red Crescent Societies (IFRC) proposal to the UK Department for International Development (DFID), (2012). Port of Spain, Trinidad and Tobago.


